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PAPERS

OF THE

PEABODY MUSEUM OF AMERICAN ARCHAEOLOGY
AND ETHNOLOGY, HARVARD UNIVERSITY

Vol. XI. — No. 1

INDIAN BURIAL PLACE AT WINTHROP, MASSACHUSETTS

BY

CHARLES C. WILLOUGHBY

WITH NOTES ON THE SKELETAL REMAINS BY

EARNEST A. HOOTON

FOUR PLATES AND TWENTY ILLUSTRATIONS IN THE TEXT

CAMBRIDGE, MASSACHUSETTS, U.S.A.
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NOTE

ACCOUNTS of a number of explorations carried on by the late Professor Frederick W. Putnam, or under his direction, remained unpublished at the time of his death. Two of the most important of these, dealing with the archaeology of Ohio, have since been brought out as parts of Volume VIII of this series, and it is hoped that others will follow.

The exploration of the small burial place at Winthrop, while merely an incident in Professor Putnam's work, is thought worthy of record owing to the early historic period to which the burials belong, and to the rarity of such discoveries in Massachusetts.

CHARLES C. WILLOUGHBY, *Director*

CAMBRIDGE, MASSACHUSETTS
April 18, 1924

INDIAN BURIAL PLACE AT WINTHROP MASSACHUSETTS

In April, 1888, workmen, excavating for the narrow gauge railroad at Winthrop, Massachusetts, just across the harbor from Boston, unearthed three or four Indian skeletons. The skull of one of these lay in contact with pieces of thin copper, evidently parts of a copper vessel which had been placed over the head. The greater part of the skull was deeply stained by the metal which had preserved portions of the hair and scalp, and what appear to be parts of the brain and its membranes, also fragments of matting and other wrappings. As soon as Mr. C. A. Hammond, superintendent of the road, heard of the discovery, he secured the skulls and such other bones as had not been destroyed, and presented them to the Peabody Museum. On August 21, Mr. Hammond wrote to Professor Putnam as follows: "We are now obliged to make further excavations in the pound [1] where relics have been found, and have already unearthed another skeleton, and more to follow, but I do not want to proceed further . . . until you can see the situation and give us some advice."

Professor Putnam was unable to go to Winthrop at the time, and arrangements were made for Mr. Hammond to discontinue the work on the road at that point for a few weeks. On November 22, the work of excavating the burials was begun under Professor Putnam's personal direction, and was continued for three days. Five graves were carefully opened. As these were the only ones within the line of the roadway which needed immediate attention, and as the weather meanwhile had become too cold to work to advantage, further investigations were postponed. On March 30, 1890, excavations were continued by Professor Putnam, and graves 8, 9, and 10 were opened. This burial place was located on the southern slope of a low sandy hill on the site now occupied by Centre Station of the Boston, Revere Beach, and Lynn Narrow Gauge Railroad. Its

[1] Built by act of the authorities of Boston dated February 23, 1634.

locality is shown on the accompanying sketch-map, plate 1, which indicates only the streets in the immediate vicinity of the station.

The positions of the skeletons are illustrated in figure 1. They were found at an average depth of about two feet, and artifacts were found in all of the graves opened by Professor Putnam, with the exception of number 3.

The pound in which the burials were discovered was built for the protection of cattle owned by the settlers of Boston. On the 23rd of February, 1634, the authorities voted that "there shall be a little house built and a sufficiently payled yard to lodge cattle in of

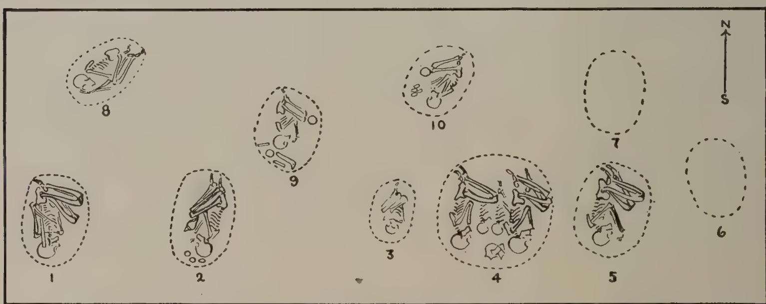


FIGURE 1

Burial Place at Winthrop: sketch-plan showing position of graves.

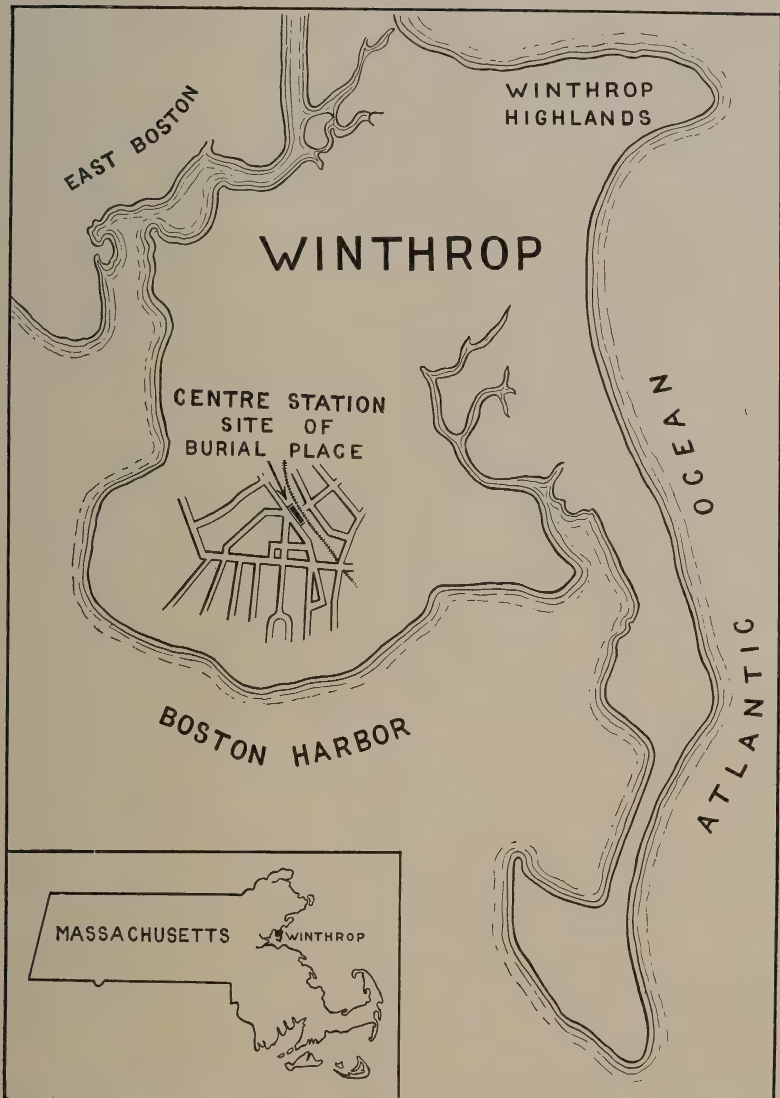
nights at Pullen Poynt Neck before the 14th day of ye next second month." [1]

At the time of the discovery of the burials (1888), the place was traditionally known as "The Pound." In 1902, Mr. Charles W. Hall wrote as follows regarding it:

> The house and palisaded yard thus erected were certainly the first built by the Massachusetts settlers within Winthrop territory. William Cheeseborough, Constable of Boston, and cattle guard at Pullen Point Neck, must have had his "corral" and house somewhere between the Court Park section and the Town Hall, as the natural water supply for the cattle was the swamp that formerly stood near the site of Winthrop Centre Station.[2]

From the above we may definitely assign to the burial place a date some time previous to 1634; and judging from the artifacts unearthed, it seems probable that the period is very near the begin-

[1] Charles W. Hall, *History of Winthrop*, 1902, p. 19. [2] *Ibid.*



Map of Winthrop, Massachusetts, showing location of Burial Place. Only the streets in the vicinity of Centre Station are indicated.

ning of the seventeenth century. This locality was in the territory of the Massachuset Indians, and the burial place undoubtedly belongs to that tribe.

The rarity of Indian cemeteries of the proto-historic period in Massachusetts makes the interments here recorded of unusual interest. The majority of Indian skeletons which have been unearthed in this Commonwealth belong to a somewhat later date, and are usually unaccompanied by artifacts.

The first burials unearthed by the workmen are not located on the plan, as their exact positions were not recorded. As already

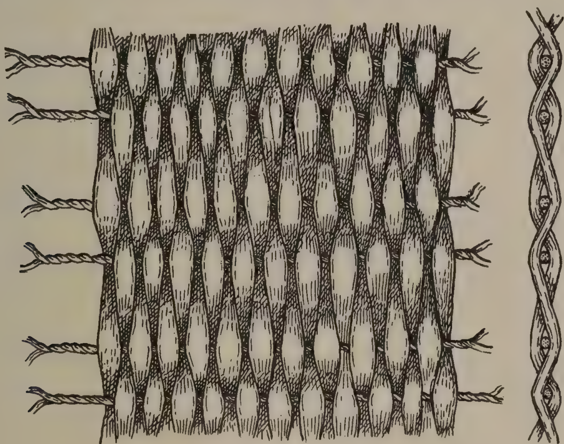


FIGURE 2
Section of bulrush mat showing weave. Found in contact with copper bowl covering skull of the first skeleton unearthed. (1/1.)

stated, the skull, which lay in contact with the copper vessel, and the adhering portions of the grave wrappings were sent to the Museum with the other bones. No pipes, beads, or other ornaments were noticed, such articles being easily overlooked.

This skull was that of an adult male, and, judging by the fragments of wrapping adhering to the copper, the burial was the result of careful preparation. The grave had apparently been lined or the body covered with birch-bark, and well-preserved pieces formed the outer portion of the adhering mass. The original pieces of bark had been sewed together with split roots. It is possible that this may have been a portion of a bark mat such as were used for portable lodge coverings by the Algonquian tribes inhabiting the birch-bark area; but the sewing does not correspond to that occurring in examples of these bark mats in the Museum from the more eastern Algonquians. Within this outer covering of birch-bark was a layer of what appears to be the bark of the cedar, and within this, and in contact with the copper vessel covering the head of the skeleton, was a piece of woven bulrush mat which had been perfectly preserved by contact with the metal. The type of weaving shown in this mat is illustrated in figure 2. The warp cords are in pairs and are undoubtedly of twisted bast; the woof is of selected rushes. According to both Roger Williams and John Josselyn, the interiors of the more permanent Indian habitations of New England were lined with "embroidered mats or with mats of rushes painted in several colors." The mats of the Ojibwa of the Great Lakes area

Figure 3
Incisors of beaver, used as chisels, Grave 1. (1/1.)

are doubtless very similar to those of the Indians of this region. The color of the groundwork of the Ojibwa mats is the natural brownish-yellow of the dried rushes, and pleasing patterns are produced in considerable variety by weaving in rushes dyed in various colors. Both Williams and Josselyn undoubtedly refer to mats which were woven in colors, not embroidered or painted. This specimen is of special interest, as it is probably the only example extant from New England. Mats from Algonquian tribes in general are usually about 3 feet wide by 5 to 7 feet long, with cross-stripes, lozenge-shaped figures, or other designs, usually in red, yellow, and black. Although coarser, they resemble some of the well-known commercial floor-mattings from China and Japan.

The metal object which lay in contact with the skull appears to

Burial Place at Winthrop: Grave 1, showing skeleton of a man with iron implement and bone arrowpoints.

have been a basin about 12 inches in diameter and 3 inches deep, made from sheet-copper. It had become corroded in places and was broken into numerous pieces. The largest fragment is about 7 by 4 inches. Many of the smaller pieces were apparently overlooked by the workmen. The edge of the basin was not turned over or wired, but was roughly cut and made smooth, probably by grinding. This may possibly have been made by an Indian workman by cutting a disc of the proper size from a sheet of copper and beating it into concavo-convex form. Similar large drinking cups of this metal were seen by Brereton in possession of the Indians of southern Massachusetts in 1602.

Grave 1. This was opened by Professor Putnam. It was 30 inches deep, and contained the skeleton of a man in a flexed position. Ly-

FIGURE 4
Bone arrowpoints, Grave 1. (1/2.)

ing parallel to the spinal column, in the position shown in plate 2, was a much corroded implement or bar of iron, $23\frac{1}{2}$ inches long, $\frac{7}{8}$ of an inch wide, and $\frac{1}{4}$ of an inch thick, one end of which tapered to a chisel-like edge.

Over this implement were five bone points and an incisor of a beaver such as were commonly hafted and used as chisels or knives (figure 3). On the opposite side of the body was another group of five bone points and a second beaver tooth. Both groups of points are illustrated in figure 4. The position of the first group is shown in the photograph. It seems probable that these points were all that remained of two groups of arrows. It will be noticed that in the first group the points lay nearly parallel with each other, with the tips in one direction, as would be the case had they been attached to shafts. The relative positions of the individual points in the second group are not recorded. It is interesting to note in this connection that the Virginia Indians used a beaver tooth, properly hafted, for notching the feathered end of their arrow shafts.[1]

Many varieties of arrowpoints were used by the New England Indians, including flint, bone, the hollowed tips of deer antler, eagle claws, tails of the horseshoe-crab, and triangular points of sheet-brass. At the time of the arrival of the colonists, sheet-brass points

FIGURE 5

One of the lumbar vertebrae of skeleton from Grave 1, showing brass arrowpoint which had been shot through the abdomen of the Indian. (2/3.)

had almost wholly replaced those of flint. The arrows were carefully made. Elder twigs were a favorite wood for the shaft, into one end of which was inserted a foreshaft of heavier wood, to which the point was attached.

Higgeson, writing in 1629 of the arrows of this region, says that some were headed with bone, some with brass.[2] These two varieties of arrowpoints were found in the grave we are describing. The one of brass had caused the death of this Indian. It was found half buried in the forward portion of one of the lumbar vertebræ, and is

[1] Captain John Smith, *Voyages and Discoveries*, Arber Edition, vol. I, pp. 364, 365.

[2] *New England's Plantations*, Massachusetts Historical Collections, 1st Series, vol. I, p. 123.

shown in position in figure 5. The arrow had been shot into the abdomen as the Indian was facing his opponent.

The only other artifacts recovered were a bead-like object of sheet-copper, one end somewhat larger than the other, and a bone point or awl, which was apparently in the earth used for filling the grave.

Grave 2. This was dug to the depth of $2\frac{1}{2}$ feet and had been lined with matting. It contained the flexed skeleton of a woman. At its left side lay an unworked shell of *Fulgur canaliculata*, a species not

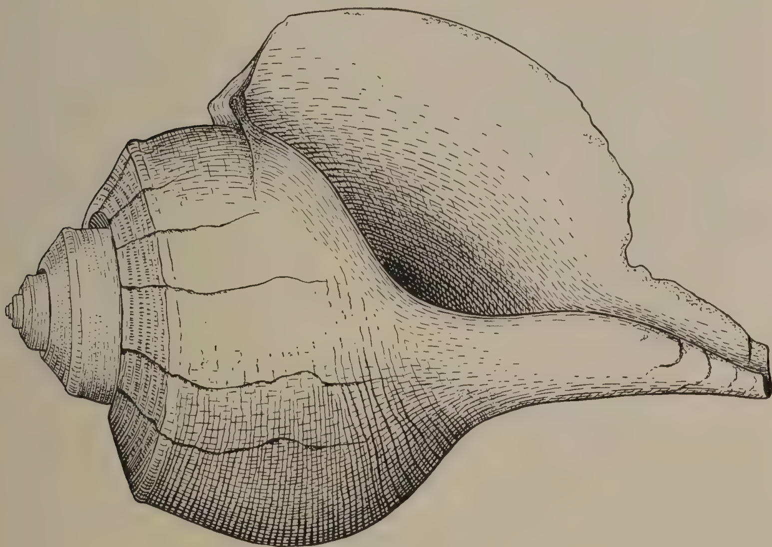


FIGURE 6

Shell of *Fulgur canaliculata* probably used as a drinking cup, Grave 2. (2/3.)

uncommon on the Massachusetts coast. This was probably used as a drinking cup or dipper (figure 6). About a foot from the skull were the three pottery vessels which are illustrated in figures 7 and 8. Near the left shoulder were also about twenty beads, approximately 4 inches in length and $\frac{1}{4}$ inch in diameter, examples of which are illustrated in figure 9, and also what appears to be a piece of a skin garment in which the body was wrapped. Each bead was made of a section of a twig, probably elder, with the pith removed, and neatly covered with thin sheet-copper, the salts of which had preserved the two-ply twisted cord with which the beads had been fastened together. These beads had not been strung end to end as a necklace, but seem to have been fastened side by side into a sort of band, similar to that taken from the Indian skeleton found near Fall River in 1831, and later made famous by Longfellow as the skeleton in armor. Beads similar to these, made of sheet-copper or brass, were quite common among the New England Indians at a very early date, and many have been taken from graves. Sheets of

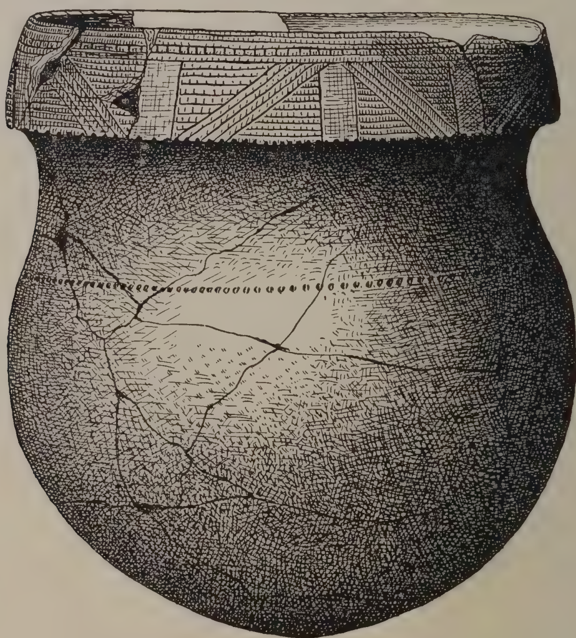


FIGURE 7
Pottery vessel, Grave 2. (1/2.)

copper and brass were undoubtedly sold to the Indians of this region by European fishermen and explorers many years before the arrival of the colonists. As early as 1524, Verrazano saw many plates of wrought copper in possession of the Indians of southern New England. These were undoubtedly of European origin. Brereton in 1602 saw among the Indians of Massachusetts:

> . . . a great store of Copper, some very red, and some of a paler colour [brass]; none of them but have Chaines, Eare-rings, or Collars of this metall;

they head some of their Arrows herewith much like our broad Arrow heads, very workmanly made. Their Chaines are many hollow pieces semented together, each piece of the bignesse of one of our reeds, a finger in length, ten or twelve of them together on a string, which they weare about their neckes: their Collars they weare about their bodies like Bandolieres a handfull broad, all hollow pieces, like the other, but somewhat shorter, foure hundred pieces in a Collar, very fine and evenly set together. Besides these they have large drinking cups made like Sculls [bowls], and other thinne plates of Copper, made much like our Boare-spear blades, all of which they so little esteeme as they offered

Figure 8
Pottery vessels, Grave 2. (1/2.)

their fairest Collars and Chaines for a Knife, or such like trifle, but we seemed little to regard it.[1]

The twisted cord on which the copper beads found with this skeleton were strung is larger and coarser than is commonly used for this purpose, and the material from which it is made has the appearance of sinew.

The three pottery vessels belong to the later Algonquian group. The clay from which they are made is of good quality and is tempered with crushed burnt shell. Cooking vessels having nearly globular bodies like these were usually suspended over the fire. The older pots with pointed bottoms belonging to the archaic group of primitive New England pottery, sherds of which are common in the older shell-heaps, were supported by hearth-stones or were set a few inches into the ground, instead of being suspended. The decoration upon these three vessels is characteristic

[1] Brereton, *Account of Gosnold's Voyage*, Mass. Hist. Coll., 3d Series, vol. VIII, p. 91.

of the pottery of this region, and consists of incised lines or depressed markings, probably made with pointed or notched sticks or similar tools. On the body of the largest vessel, and also on the one illustrated in figure 10, are faint impressions of cord-wrapped paddles such as were used in pottery making over an extensive area east of the Mississippi River.

The round-bottomed pottery of the later New England Algonquians has many characteristics of Iroquoian ware. The Iroquois were excellent potters, and while the clay vessels of the two peoples are as a rule easily distinguished, the influence of the work of these

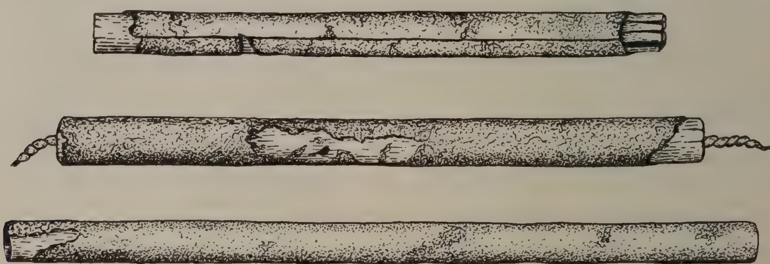


Figure 9

Tubular beads of elder wood covered with thin sheet-copper, Grave 2. (1/1.)

New York tribes was marked on the fictile art of the natives of the southern portion of New England.

The so-called "Red Paint" people, the oldest New England Indians of whom we have knowledge, made no pottery. The earliest New England potters were undoubtedly the Algonquian tribes whose refuse is found on many of the older village sites inland, and especially in the ancient kitchen-middens or shell-heaps of our tidewater region. The broken pottery from these sources shows that the bottoms of the pots were more or less pointed. These vessels could not stand upright without being supported by a tripod of stones, or by being set with the pointed bottom an inch or two in the earth. This older type of pottery extended southward along our coast to Virginia, where it was used as late as the latter part of the sixteenth century. Hariot describes its use as follows:

> After they set them upon a heape of earth to stay them from fallinge, they putt wood under which being kyndled one of them taketh great care that the fyre burn equallye rounde abowt.

The more or less globular bodies of the pots from these graves, however, taken in connection with their restricted necks, seem to indicate that they were intended principally for suspension by means of a band encircling the vessel below the rim, to which cords or thongs were fastened.

The rounded bottoms suspended a few inches from the live coals would expose a large surface to the direct heat, without obstructing the draft or deadening the fire. In "Mourt's Relation" we have a description of an Indian wigwam at Cape Cod in 1620. In the midst of this mat-covered house was the fireplace, where were found "four little trunches [crotched sticks] knockt into the ground and small sticks laid over on which they hang their pots and what they had to seeth." [1]

The few other references to the earthenware of the Indians of eastern Massachusetts are as follows. Gookin in 1674 writes:

> The pots they seeth their food in, which were heretofore and yet are in use among some of them are made of clay or earth, almost in the form of an egg with the top taken off. But now they generally get kettles of brass, copper or iron. These they found most lasting than those of clay, which were subject to be broken, and the clay or earth they were made of was very scarce and dear.[2]

Morton tells us:

> They have earthen potts of divers sizes, from quart to a gallon, 2 or 3, to boyl their vitels in, very strong though they be thin like our iron pots.[3]

Champlain found pottery in use along the Massachusetts coast, and says that "when the natives eat Indian corn they boil it in earthern pots which they make in a different way from ours." [4]

Of the many New England potsherds examined by the writer, only one or two show indications that the vessel of which they formed a part may have been made by the coiling process.

It seems doubtful if this method, so common in the West, was used to any great extent by the northeastern tribes. The following, as quoted by Laverdière, from Sagard's "History of Canada," written in 1636, doubtless refers to Iroquoian potters; the description may apply as well to the Algonquian potters of New England:

[1] *Journal of the Pilgrims at Plymouth* (London, 1622), Cheever's Reprint, p. 39.
[2] Gookin, Mass. Hist. Coll., 1st Series, vol. I, p. 151.
[3] Thomas Morton, *New English Canaan* (1637), Prince Society Reprint, p. 159.
[4] *Champlain's Voyages*, Prince Society Reprint, vol. II, p. 86.

They are skilful in making good earthen pots which they harden very well on the hearth, and which are so strong that they do not, like our own, break over the fire when having no water in them. But they cannot sustain dampness nor cold water so long as our own, since they become brittle and break at the least shock given them; otherwise they last very well. The savages make them by taking some earth of the right kind, which they clean and knead well in their hands, mixing with it, on what principle I know not, a small quantity of grease. Then making the mass into the shape of a ball, they make an indentation in the middle of it with the fist, which they make continually larger by striking re-

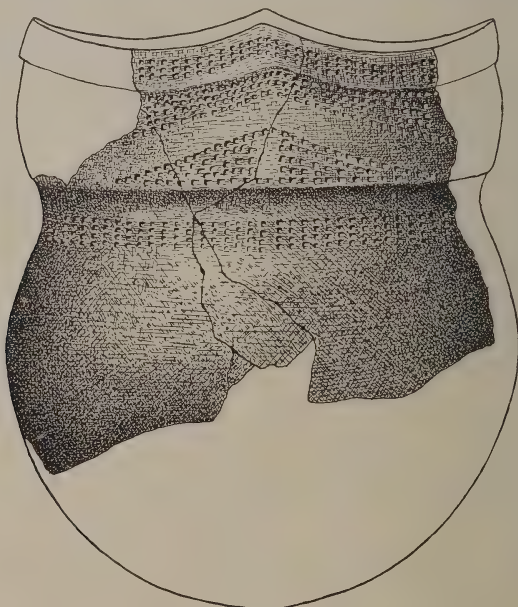


FIGURE 10
Pottery vessel, Grave 4. (1/2.)

peatedly on the outside with a little wooden paddle as much as is necessary to complete it. These vessels are of different sizes, without feet or handles, completely round like a ball, excepting the mouth, which projects a little.[1]

Grave 3. Skeleton of a child about one year old, at a depth of 2 feet. No artifacts were found with it.

Grave 4. A shallow grave containing the skeletons of a man, a woman, and two children, in the positions shown in plate 3. Fragments of the pottery vessel, illustrated in figure 10, lay near the

[1] *Champlain's Voyages*, Prince Society Reprint, vol. II, p. 86, note.

Burial Place at Winthrop: Grave 4, showing skeletons of a man, woman, and two children, and a broken pottery vessel.

head of the woman. Beneath her head were 80 blue and white tubular glass beads, $\frac{3}{8}$ to $\frac{5}{8}$ of an inch long and of various diameters, also a few copper beads of about the same size. There were also found in this grave 148 white beads made from the columella of one of the larger univalves, probably *Fulgur carica* or *Fulgur canaliculata*, and a few small discoidal beads of mussel shell (plate 4). The white beads are of ancient type and were made before the common white and purple wampum became the vogue among the Indians of New England and the Middle States. This later commercial wampum, made principally from the shell of the quahog, was introduced into New England by the Dutch about 1628.

Grave 5. A much decayed skeleton of a man lay 2 feet below the surface. The earth at this point was less sandy than the other

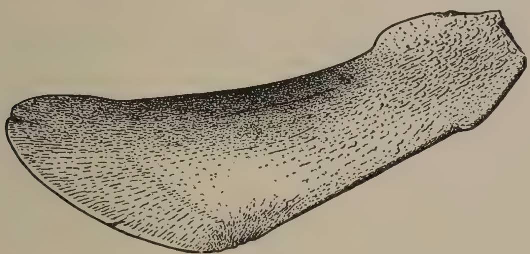


FIGURE 11
Spoon made of antler, Grave 9. (1/2.)

sections of the cemetery, and the dampness caused a more rapid disintegration of the bones. The only artifacts found were a few tubular white shell beads and five tubular glass beads which lay beneath the jaw.

Graves 6 and 7. Unearthed by workmen. Exact locality unrecorded. No artifacts found with skeletons.

Grave 8. Skeleton of man, 2 feet below the surface, in the usual flexed position, and facing southeast. The only implement recovered was a bone awl lying about 4 inches back from the vertebral column.

Grave 9. This contained the skeleton of a child, two to three years old, at a depth of 14 inches, and judging by the objects found, it must have been a girl. Near the head were fragments of a pottery vessel of about the size and shape of the one illustrated in figure 7; also the antler spoon shown in figure 11. Nearby lay the stone pestle (figure 12) with its upper portion carved to represent the head of an animal, also the small water-worn stone (figure 13) which resembles the ordinary polishing or sharpening stone although it shows no sign of use. As one end of the stone somewhat resembles an animal head, it seems not unlikely that this may have been a toy. Near the knees of the skeleton was found the small pottery vessel illustrated in figure 14. This also was probably a toy. The only other artifact recovered was a bone point, which may have been thrown into the grave with the earth when covering the body.

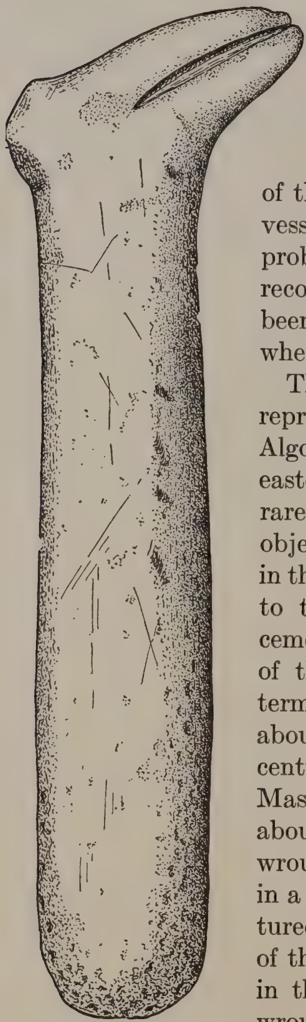
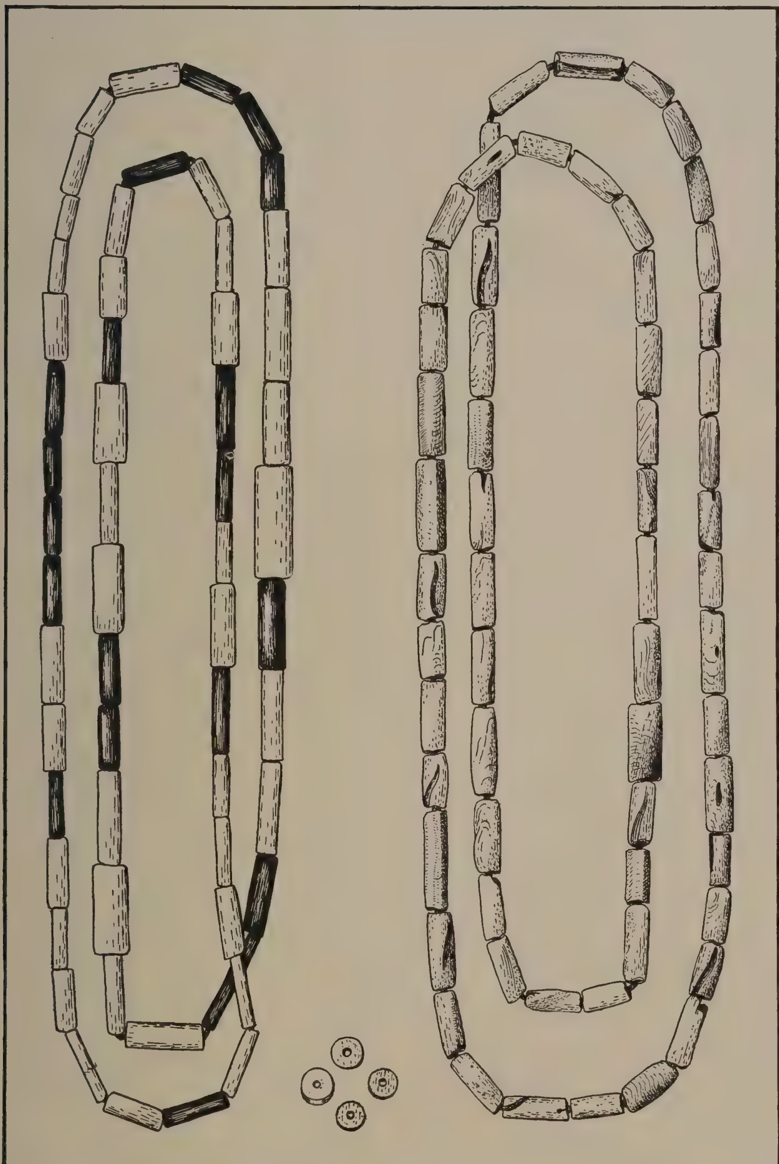


FIGURE 12
Stone pestle, Grave 9.
(1/2.)

The pestle is of considerable interest as it represents a type not uncommon among the Algonquian tribes of New England and the eastern sections of the Middle States, but rare in the adjacent regions. Although no object of European provenience was found in this grave, the burial undoubtedly belongs to the same period as the others in this cemetery, which would indicate that pestles of this general form, with or without the terminating animal head, were used up to about the beginning of the seventeenth century. Judging from the collections from Massachusetts in the Peabody Museum, about five per cent of the more carefully wrought stone pestles terminate at one end in a knob or a more or less carefully sculptured head of an animal. The best example of this type known to the writer was found in the Kennebec Valley, and has a finely wrought human head at the upper extremity. These pestles are of various lengths, up to about 28 inches, and are commonly about 2 to $2\frac{1}{2}$ inches in diameter. They are usually made of a variety of metamorphosed slate, and are generally gray or greenish in color.



Burial Place at Winthrop: Blue and white tubular glass beads (at left); tubular beads of shell, and small discoidal beads of mussel shell, all from Grave 4. (1/1.)

They were probably used with wooden mortars made by burning a hole in the end or the side of a section of a tree trunk. There is an old Indian mortar and pestle from Nantucket in the Peabody Museum. The mortar is made from a section of an oak tree trunk. It is about 20 inches high, 9 inches in diameter, and has a cavity about 10 inches deep. This is probably similar to the larger mortars used in prehistoric times in New England. With such mortars the longer

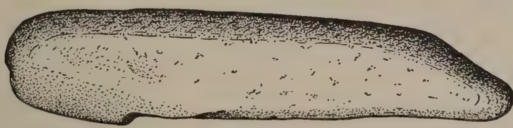


FIGURE 13
Water-worn stone remotely resembling a small animal, Grave 9. (1/2.)

stone pestles were probably used. It is also probable that long wooden pestles similar to those still common among the Algonquians of the Great Lakes region were used in these mortars. The pestle that accompanies the old mortar above mentioned is about 30 inches long, and is of wood with the exception of the lower portion, which consists of a short piece of an ancient stone pestle fitted to the wooden handle and bound with an iron band. The smaller stone pestles were probably used in wooden mortars of relative size, and were doubtless for preparing maize foods, "medicine," and other substances.

FIGURE 14
Toy pottery vessel, Grave 9. (1/2.)

Schoolcraft figures, on plate 21 of the fourth volume of his work, a woman grinding corn. There is an ancient stone pestle, with a head at its upper end, suspended by a cord from the limb of a tree which serves as a spring-pole. A very broad and shallow mortar of stone is shown below. In connection with this picture are two views of the stone pestle drawn to a much larger scale. On page 175, under the caption "Relics from New Hampshire," is the following reference to this illustration:

> The mode of pounding maize by suspending a stone pestle from the limb of a tree as practised by the ancient Pennacooks of the Merrimack Valley in New Hampshire is represented in plate 21. The pestle is commonly ornamented by

the head of a man or quadruped, neatly carved from greywacke, or compact sandstone, the mortar being also of the same material.

This reference has been widely quoted. It seems apparent, however, that Schoolcraft was describing a stone pestle found in the habitat of the Pennacook Indians in the Merrimack Valley which he figures separately, and that his accompanying drawing showing a woman using this same pestle is wholly ideal. Stone mortars of Indian origin, such as is shown in this drawing, if they occur at all in New England, are extremely rare.

Referring previously to the use of the spring-pole in connection with the mortar and pestle, Schoolcraft says (vol. III, page 467):

After the introduction of the iron axe consequent on the discovery, stumps of trees were excavated to serve the purpose of a mortar, a practice which com-

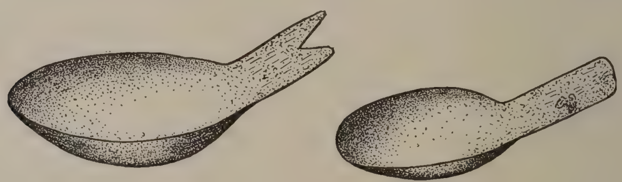


Figure 15
Spoons: the larger is made of sheet-brass, the smaller of sheet-copper, Grave 10. (1/2.)

mended itself to the early back settlers who improved on the idea by attaching the wooden pestle to a spring-pole loaded in such a manner as to lift the pestle from the block with but little effort.

It seems doubtful, therefore, if the spring-pole was used by the New England Indians in ancient times.

Grave 10. Skeleton of a child two to three years of age, probably a boy. Near the foot of the grave were fragments of a pottery vessel. Near the extremity of the forearm lay a deposit consisting of two spoons, the larger made of sheet-brass and the smaller of sheet-copper (figure 15); 5 pendants and a disc having two perforations, all of sheet-brass (figure 16); a terra-cotta pipe (figure 18); the remnants of a bag of coiled netting which had evidently contained the pipe; and what may have been the remains of a second bag, probably of dressed skin, which perhaps had held the metal spoons. With these objects were several seeds, resembling those of a variety of the *Cornus*, having the ends ground down to the cavity, thus forming a perforation for the purpose of stringing for use as beads. With the skeleton were also several glass beads, both blue and white, of the same kind as those shown in plate 4; and the iron adze blade illustrated in figure 17.

Roger Williams says that "generally all the [Indian] men throughout the country have a tobacco bag with a pipe in it hanging at their back." It was doubtless such a bag which was placed in this grave. It was of coiled netting (figure 19), a style of fabric used principally for bags by various tribes of both North and South America, and also found among the natives of Africa and the Pacific Islands. The foundation for the mouth of these bags was a cord over which the first coil of the bag was looped, as indicated in the drawing. This looped coiling was continued spirally downward, the

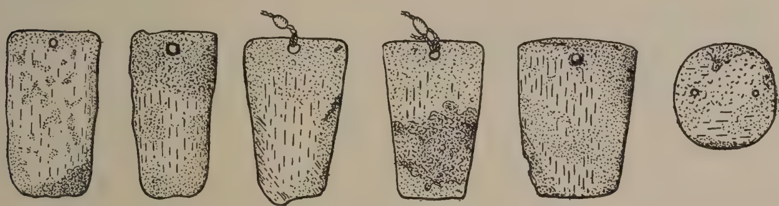


FIGURE 16
Pendants and disc of sheet-brass, Grave 10. (1/2.)

lower portions of the bag being drawn in gradually until the center of the bottom was reached. The texture is shown more open in the illustration than in the original, for the purpose of making the technic clearer. This is the first record of the occurrence of this fabric among the natives of New England.

So little remains of what appears to be a second bag that it is impossible to tell the material of which it was made. It was probably of dressed skin, however, and was apparently ornamented with the brass pendants and disc (figure 16); beads made from seeds; and a double fringe of hair, a section of one layer of which is shown in figure 20.

The tobacco pipe is of a type evidently fairly common at the beginning of the seventeenth century, and probably also at a much earlier date. It is of terra-cotta, and of a form occurring among the eastern Algonquians from Virginia northward, to and including the southeastern portion of New England. This specimen has its stem covered with a piece of sheet-brass, very neatly joined. The majority of these pipes, however, are without this metal reinforcement. Gosnold in 1602 saw among the Indians in the vicinity of Buzzards Bay, southern Massachusetts, pipes "steeled with copper." Brereton's account is more explicit. He says:

> the necks of their pipes are made of clay, hard dried . . . the other part is a piece of hollow copper very finely closed and cemented together.[1]

This is a very good description of the pipe from this burial. There are two other terra-cotta pipes in the Museum from Massachuset Indian graves in the vicinity of Boston, having bowls also bound with sheet-brass. It is probable that the stems of both were originally covered with the same material, for one still retains a narrow band of brass just below the bowl, and the lower portion of the other had evidently been cut down to fit a tapering metal stem.

FIGURE 17
Adze blade of iron, Grave 10. (1/2.)

During this period, stone tobacco pipes with figures of men or beasts in relief upon them were also in use by our Indians. This is shown by the accounts of contemporary writers, and by archæological investigations. The platform pipe, however, frequently found in this region seems to belong to an earlier period.

The two spoons found near the bag containing the pipe were neatly made, the larger of sheet-brass and the smaller of sheet-copper. The concavo-convex form of the bowls may have been produced by hammering that portion of the unfinished spoon into a corresponding depression in a block of wood with a round-faced hammer of some kind, a method followed by our sheet-metal workers in making various objects, up to quite recent times. The edges of the spoons are ground smooth. If they were originally cut with heavy shears, or if they were finished with a file, all traces seem to have been removed by grinding. The edges of the brass pendants appear to have been finished in the same manner, but the perforations in the pendants were doubtless produced with an iron punch, as the bur upon the under side is very marked. The copper basin found with the first burial described was doubtless shaped by the

[1] Brereton, op. cit. p. 88.

same process as were the bowls of the spoons. The metal handles of the spoons are very short, and it seems reasonable to suppose that they were originally attached to longer handles of wood. On the whole, it seems probable that the basin and spoons were made by Whites who possessed only crude tools, although it is possible that they were worked out of sheet metal by the Indians.

The occasional finding of tobacco pipes in graves of young children is an interesting indication of the affectionate forethought of the parents for the future comfort and welfare of the departed boy. It seems to indicate a belief in the continued growth and maturity

FIGURE 18

Terra-cotta tobacco pipe with stem covered with sheet-brass and wound with sinew, Grave 10. (2/3.)

of the spirit, for it is hardly probable that these very young children were users of tobacco at the time of their death.

Throughout the century following the discovery of Newfoundland by Cabot in 1497, ships from various nations of Europe visited the northeastern coast of America, and had more or less communication with the natives. Verrazano, the Florentine explorer, reached the eastern coast of America in 1524, and turning northward explored the bays and inlets to about the latitude of eastern Maine. He gives an accurate account of the Indians of southern New England, and describes their habitations, dress, canoes, agriculture, etc. He writes as follows of the copper found among them:

> We saw many plates of wrought copper which they esteem more than gold, which for the color, they make no account of, for that among all other is accounted the basest. They make most account of azure and red. The things they esteemed most of all those which we gave them were bells, crystals of azure color, and other toys to hang at their ears and about their necks.[1]

This copper must have been obtained from previous explorers of whom we have no account; for although an occasional implement

[1] *Relation of John Verrazano*, Hakluyt's Divers Voyages, Hakluyt Society Reprint, p. 65.

and a few small beads have been found, wrought from native copper, nothing in the way of metal plates or large beads has been recovered in New England which was not made of European copper or brass. It has been suggested that much of the sheet metal was obtained from wrecked ships. It seems much more probable that it was acquired in trade with the early fishermen and explorers, many of whom undoubtedly skirted our New England shores in the sixteenth century. In 1535, Cartier sailed up the St. Lawrence. It appears that the English trade "out of England to Newfound land was common and frequented" as early as 1548.[1]

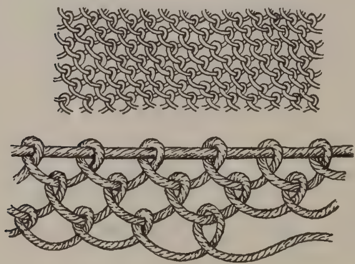


FIGURE 19

Section of bag of coiled netting, the lower enlarged drawing showes the technic more clearly, Grave 10. (1/1.)

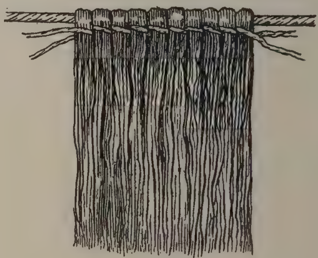


FIGURE 20

Section of layer of fringe, probably a part of bag, Grave 10. (1/1.)

In 1578, Anthonie Parkhurst wrote a letter to Richard Hakluyt, a portion of which is as follows:

Now to answer some part of your letter touching the sundry navies that come to Newfoundland or Terra nova, for fish: you shal understand that some fish not neere the other by 200. leagues, and therefore the certaintie is not knowen; and some yeres come many more than other some, as I see the like among us: who since my first travell being but 4. yeeres, are increased from 30. sayle to 50. which commeth to passe chiefly by the imagination of the Westerne men, who thinke their neighbours have had greater gaines then in very deed they have, for that they see me to take such paines yeerely to go in proper person: they also suppose that I find some secret commoditie by reason that I doe search the harbors, creekes and havens, and also the land much more than ever any Englishman hath done. Surely I am glad that it so increaseth, whereof soever it springeth. But to let this passe, you shall understand that I am informed that they are above 100. saile of Spaniards that come to take Cod besides 20. or 30. more that come from Biskaie to kill Whale for Traine. These be better appoynted for shipping and furniture of munition, then any nation sav-

[1] *Hakluyt's Voyages* (Glasgow Edition, 1904), vol. VIII, p. 9.

ing the Englishmen, who commonly are lords of the harbors where they fish, and do use all strangers helpe in fishing if need require, according to an old custome of the countrey, which they do willingly, so that you take nothing from them more then a boat or twaine of salt, in respect of your protection of them against rovers or other violent intruders, who do often put them from good harbor, &c. As touching their tunnage, I thinke it may be neere five or sixe thousand tunne. But of Portugals there are not lightly above 50. saile, whose tunnage may amount to three thousand tuns, and not upwarde. Of the French nation and Britons, are about one hundred and fiftie sailes, the most of their shipping is very small, not past fortie tunnes, among which some are great and reasonably well appointed, better then the Portugals, and not so well as the Spaniards, and the burden of them may be some 7000. tunne. Their shipping is from all parts of France and Britaine, and the Spaniards from most parts of Spaine, the Portugals from Aviero and Viana, and from 2. or 3. ports more. The trade that our nation hath to Island maketh, that the English are not there in such numbers as other nations.[1]

From the above we learn that at this date there were evidently nearly 400 European vessels engaged in taking fish or whales, and probably a portion of them incidentally trading for furs, in an area 600 miles in diameter in the vicinity of Newfoundland and Cape Breton. The New England coast was doubtless within this 600 mile area, and there seems to be no reasonable doubt that it was visited by many of these ships and that there was more or less intercourse between these vessels and the natives. This seems to be the most reasonable explanation of the origin of the quantities of copper and brass objects recorded by early writers as in possession of the Indians of this region, and it doubtless explains their presence in early proto-historic graves of the tidewater region. It may also explain the presence of certain unusual forms of porcelain and glass beads.

In September, 1907, the attention of the writer was called to the finding of an Indian cemetery on the slope of a hill in Ipswich, Massachusetts, where the land was being graded. One or two graves were uncovered, and with the burials were found a terra-cotta pipe similar to the one illustrated in figure 18, but without the brass binding on the stem; a bracelet of small beads of sheet-copper strung alternately with blue glass beads; a necklace of small white porcelain beads of oval form; and the bronze brazier shown in figure 21. Only a few fragments of bone were recovered.

Obtaining permission, in behalf of the Museum, of the owner of

[1] *Hakluyt's Voyages* (Glasgow Edition, 1904), vol. VIII, pp. 9–11.

the estate, Mr. F. B. Harrington, investigations were carried on at the burial place for several days. A few additional graves were opened, but no artifacts were found. In each of these graves the skeletons had disintegrated, leaving nothing but a whitish paste in the damp soil in place of the bones. This, upon drying, turned to powder. Not a tooth was recovered. The bodies had been interred in a soil composed largely of clay, which allowed the water to

FIGURE 21
Bronze brazier from an Indian grave at Indian Hill, Ipswich, Massachusetts. (1/3.)

percolate but slowly; consequently the disintegration of the bones was probably more rapid than it would have been had they been buried in sand or gravel.

Not being able to determine the provenience of the brazier from collections in our colonial museums, inquiries were made at the British Museum, at the Museum at Hull, England, and at the Museo de Anthropologia, Madrid. No reply has come from Madrid. From the first institution, the following was received:

> We have two or three bronze (not brass) braziers with a general similarity to the one of which you enclose a photograph. One has projections rising from the rim in a similar manner, presumably to support a vessel placed above, but they have no curves and are not so "spiky." We have no precise data to help us in dating, but regard our specimens as late 15th or early 16th Century.

From the Hull Museum we received the following:

> In reply to your letter of the 5th instant, the object shown on the photograph seems to be a brazier, is probably late 16th Century in date, and appears to be of Spanish origin.

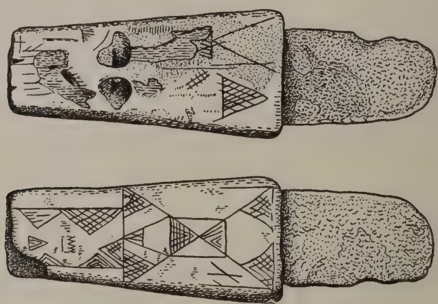
If the last identification is correct, the specimen must have been obtained from a Spanish or Portuguese ship which communicated with the Massachuset Indians during the latter half of the sixteenth century.

No exhaustive study has been made of the various types of glass and porcelain beads which have been recovered from Indian graves of eastern New England. When this is done it may throw additional light on the intercourse of the natives with the sixteenth century fishermen and traders.

Previous to the arrival of the colonists, the most valued articles obtained from the Whites were probably glass beads, and sheet-copper and brass. There seems to be no evidence that European cloth was sold to the Indians during this period. After the colonists became established, many well-made brass and copper kettles of various sizes and forms were obtained by barter, in addition to sheets of these metals, which were still in demand. The Indians also were able to procure European cloth, cast brass spoons, glassware, crockery, etc., and an occasional object of pewter, all of which have been found in graves dating about 1625 to 1670.

During the latter part of the seventeenth century, however, a considerable change took place in the burial customs of this section, especially among the so-called Christianized Indians, and most of such graves which have been opened contain no artifacts and the skeletons are usually in a horizontal position.

The long cultivation of the fields of this Commonwealth, the grading of lands, and the many excavations preliminary to building houses and roads, have brought to light relatively few Indian graves as compared with many sections of this country. These graves have usually been found singly or in small groups, and many were without artifacts. Their discovery has usually been under conditions which did not allow careful investigation by experienced excavators, therefore it is hoped that the foregoing account will prove of special value to those interested in the archæology of our northern Atlantic seaboard.



Knife with antler handle, and blade probably made from a piece of brass kettle. Found with an Indian skeleton on Hermon Street, Winthrop, in 1886. The handle is of a type originally used for flint blades. (1/2.)

NOTES ON THE SKELETAL REMAINS

By EARNEST A. HOOTON

These remains from the Winthrop cemetery consist of incomplete skeletons of seven adult males, four adult or sub-adult females, and five infants. Two of the skeletons of males are well preserved, as is also the skeleton of one female. But none of them is complete. Several skeletons are represented only by calvariae or skull fragments.

In connection with the cranial measurements and indices, the most important morphological features of the various crania are described. Following this, a brief consideration of the salient characters of the long bones accompanies the table recording their measurements and indices.

60380, Grave 1. This is the skeleton of a young adult male. The brain case is of good size and very dolichocephalic (71.4). It is also hypsicephalic (75.0) and akrocephalic (105.1). The frontal region is of medium breadth, but low and retreating; the sagittal region has a very pronounced median elevation; the temporal regions are flat, with moderate supramastoid crests, and the occipital region is moderately convex, and has a slight torus.

The serration of the sutures is simple, and obliteration has begun externally only in the obelion region of the sagittal suture. There are a few small Wormian bones in the lambdoid suture, and one in each of the squamous sutures. There is also a very small bone in the right side of the coronal. The pterions are of the usual medium H-form, and there are no parietal foramina. One small right retromastoid foramen, and one small and one medium left foramen were observed. The mastoids are of medium size.

The brow-ridges are large and divided into median and lateral portions. There is a moderate depression at nasion. The nasal bridge is narrow, of medium height, and concavo-convex in profile. The moderately broad nasal aperture shows lower borders of fair development and a large nasal spine. The orbits are low and broad, with a medium inclination of their horizontal axes. There are no infraorbital sutures, and the suborbital fossae are shallow. Malars and zygomata are very large. Only a slight alveolar prognathism is apparent.

The dentition is complete, but seven of the molars have been lost in life. The crowns of the teeth are much worn, and the quality is a little below the average for Indians. The palate is elliptical in shape and has a medium torus. The glenoid fossae are deep, with well-developed postglenoid processes. The styloids are very large. The middle lacerate foramina are of medium size, and the depression of the petrous parts of the temporal bone is about average, as in typical Europeans. A complete pterygo-spinous foramen occurs on the right side, and indications of one are found on the left side. There are no dehiscences in the floor of the auditory meatus. The muscular impressions on the skull are well marked.

The mandible is large, with a well-developed chin eminence, stout ascending rami, and everted gonial angles. The mylo-hyoid ridge and genial tubercles are well developed.

This is a typical Eastern Indian dolichocephal. The facial index is mesoprosopic, and the gnathic index shows no prognathism. The orbits are chamaeconch, the nose is leptorrhine, the palatal index is brachyuranic, and the capacity (1480 cc.) is above average for Indians.

60388, Grave 8. This is the skeleton of a middle-aged adult male. The frontal region is low and retreating, but broad. The sagittal region has a slight elevation and the breadth is narrow. A slight postcoronoid depression is noticeable. The temporal region is flat, with a small supramastoid ridge. The occipital region is of medium convexity, with traces of a torus. The serration of the sutures is simple. Obliteration is far advanced in the sagittal suture, the external thirds of the coronal suture are closed, and obliteration is beginning in the lambdoid. There is one medium Wormian bone in the lambdoid suture. The pterions are of a medium H-form. There is one small parietal foramen on the right side and one medium on the left. On the left side there are one medium and two small retromastoid foramina, and on the right side one medium and three small. The mastoids are large. The brow-ridges are prominent and divided into medium and lateral portions. There is a small depression at nasion, and the nasal bridge is of medium height and breadth. In profile it is concavo-convex.

The nasal aperture is broad, with a moderate development of the lower borders and the nasal spine. The orbits are low and oblong in shape, with the horizontal axes slightly inclined. There are no infraorbital sutures, and the suborbital fossae are shallow. The malars and zygomata are large, but alveolar prognathism is slight.

The dentition is complete, and the teeth are moderately worn and of fair quality. Several abscesses, caries, and traces of pyorrhoea are evident. The number of cusps of the molar teeth cannot be counted, nor is it possible to ascertain the presence or absence of shovel incisors. The palate is parabolic in shape, with a moderate torus. The glenoid fossae are of medium depth and show a medium postglenoid process. The styloids are small. The middle lacerate foramina are large, and the depression of the petrous portions of the temporal bones is about the average for Europeans. The posterior lacerate and postcondyloid foramina are ordinary. The foramen magnum is hexagonal. Partially formed pterygo-spinous foramina are present.

The mandible is large, with a well-developed mental process. The mylo-hyoid ridge is submedium in development, but the genial tubercles are average. Slight traces of a mandibular torus may be noticed.

60379, Unearthed by workmen. The calvaria is that of a middle-aged male. The frontal breadth is very narrow, and the maximum breadth occurs at the level of the parietal tuberosities. The skull is high, short, and of rather small breadth. It is subbrachycephalic (78.09), and appears to be the result of the admixture of a dolichocephalic element with a brachycephalic element.

The frontal region is of medium height, but narrow and very receding. In the sagittal region there is a slight median elevation and a slight postcoronoid depression. The temporal region is protuberant, with a slight supramastoid crest. The occiput shows a moderate convexity.

The sutures are simple in serration. The sagittal suture is about one-half obliterated, and occlusion has begun in the coronal. The lambdoid suture is open. There is an apex bone in this suture and a small Wormian bone in the right squamous suture. The pterions are of the usual H-form. One small parietal foramen occurs on the right side, and two medium retromastoid foramina on the left side. The mastoids are of medium size. The brow-ridges are moderately developed and confined to the medial portions of the orbits. The facial portion is missing.

The glenoid fossae are of medium depth and there are no postglenoid processes. The base of the skull shows no unusual features. There is a medium sized dehiscence in the floor of the left auditory meatus. The mandible is of medium development and size, except that the mylo-hyoid ridges and genial tubercles are poorly marked.

45651, Unearthed by workmen. This is the partially mummified skull of a young adult male subject. The scalp, hair, and integument are preserved on the right half of the cranium. This condition is probably due to the fact that the skull was covered with a brass vessel, for the mummified tissues and the adjacent bony parts show green copper stains. The skull is subbrachycephalic (79.35), hypsicephalic (81.52), and akrocephalic (102.74).

The frontal region of the skull is medium in height, breadth, and slope. The sagittal region shows a slight median elevation. The temporal regions are rather flat. The occipital region is steep, with traces of a torus. The sutures are simple, and obliteration has begun dorsally in the pterion regions. The half of the skull uncovered shows no Wormian bones. The left side shows one large, one medium, and one small retromastoid foramen, and the mastoid process is of medium size.

The brow-ridges are limited to the median halves of the supraorbital region and show average development. The nasion depression is slight. The nasal bridge is low, of medium breadth, and concavo-convex in profile. The nasal aperture is broad, with indistinct lower borders and a small spine. There are traces of subnasal grooves. The orbits are oblong, with no inclination of their horizontal axes. On the left side an infraorbital suture is about one-half complete. The suborbital fossae are medium; the malars and zygomata are large. Alveolar prognathism is very slight.

The dentition is complete, and the wear of the teeth is slight. The teeth are of good quality. The cusps of the upper molars show a 4–3–3 formula, and the lower molars 5–4–?. The third molars are much reduced in size. Traces of shovel incisors may be observed. Observations and measurements on the palate and teeth are incomplete, because the mandible cannot be disarticulated without destroying the mummified tissues. The palate is parabolic, with a slight torus. The glenoid fossae are deep, with marked postglenoid processes. The styloids are rudimentary. The other features of the skull base, so far as observable, are ordinary. Incomplete pterygospinous foramina are present.

The mandible is large, with a prominent chin, and a medium development of other morphological features.

The hair preserved is straight and black, but rather fine in quality. The interior of the skull still contains the dried mass of the brain tissues.

60377, Unearthed by workmen. Fragmentary calvaria of a middle-aged male. The length-breadth index is subdolichocephalic (75.81). The frontal region is of medium breadth, but low and retreating. The sagittal region has a slight median elevation. The temporal region is moderately convex, as is also the occipital region. The sutures are simple in serration. The sagittal suture is half obliterated, and, in the coronal, obliteration has begun in the lateral portions. The lambdoid suture also shows beginnings of external obliteration. There are no Wormian bones. Two very small parietal foramina are found on the right side, and there are one small right and two small left retromastoid foramina. The mastoids are of medium size, but the brow-ridges are small and divided into medial and lateral portions. The facial portion is fragmentary. The nasal aperture is broad. It has no lower borders; the nasal floor slopes off into an alveolar clivus without definite transition. The nasal spine is rudimentary. The orbits are oblong, low, and horizontal. There are no infraorbital sutures. The suborbital fossae are shallow. There is a moderate degree of alveolar prognathism.

The dentition is complete and the crowns of the teeth are markedly worn. Three molars have been lost in life, and there are traces of five alveolar abscesses, but the general quality of the teeth is good. The cusps cannot be counted. Evidently the third molars are much reduced in size. The palate is of the usual parabolic shape. The base of the skull shows a medium development in all features.

The mandible is large and heavy, with thick everted gonial angles and extensive attachments of masticatory muscles. The mental prominence is submedium in development. Other features are ordinary.

60383, Grave 4, Eastern skeleton. Skeleton of a middle-aged male. The skull is fragmentary, but seems to have been about 192 mm. long and approximately 140 mm. broad. It was, then, pronouncedly dolichocephalic. The frontal region of the calvaria is

MEASUREMENTS OF CRANIA

Catalogue number Sex Age	**60380** Male y. ad.	**60388** Male mid.	**60379** Male mid.	**45651** Male y. ad.	**60377** Male mid.	**60384** Female sub.ad.	**56669** Female y. ad.	**60378** Female mid.
Deformation	...	...	...	...	...	...	...	...
Glabello-Occipital length	192	187	178	184	(186)	167	169	178
Maximum breadth	137	135	139	146	141	133	133	140
Basion-Bregma height	144	140	138	(150)	?	142	137	136
Min. Frontal diameter	98	102	89	(98)	98	85	91	92
Total Facial height	126	132	?	(117)	?	110	?	?
Upper Facial height	79	(76)	?	70	?	68	71	?
Bizygomatic diameter	147	(148)	?	140	?	(124)	?	?
Bigonial diameter	110	106	?	107	107	97	?	?
Height of Symphysis	38	39	?	35	35	33	?	?
Bicondylar width	(138)	?	?	?	?	113	?	?
Min. breadth of Ascending Ramus	40	40	37	43	41	37	?	?
Height Ascending Ramus	70	64	58	?	61	50	?	?
Condylo-Symphyseal length	109	119	?	?	115	100	?	?
Height of Orbits: right	35.5	36	?	?	?	31	?	?
left	35.5	36	?	29	?	31	36	?
Breadth of Orbits: right	45	46	?	?	?	38	?	?
left	45	46	?	39	?	36.5	38	?
Nasal height	58	52	?	51	?	51	50	?
Nasal breadth	26	27	?	27	27.5	24	25	?
Basion-Alveon	104	(104)	?	(103)	?	98	101	?
Basion-Nasion	111	114	?	107	?	103	102	?
Palate: External length	58	61	?	(57)	58	53	53	?
External breadth	70	72	?	?	68	64	59	?
Maximum circumference (above brow-ridges)	520	521	496	(520)	(515)	476	485	505
Arc: Nasion-Opisthion	375	373	365	(382)	?	351	345	370
Arc: Transverse	303	303	314	(327)	(320)	301	298	312
Foramen magnum: length	40	32	35	35	?	33	39	35
breadth	37	32	29	33	?	30	32	35
Thickness of Left Parietal (above squamous suture)	5.3	3	7	(4.6)	(4.6)	3	3.6	5.3
Capacity	1480	1530	?	?	?	1310	1280	1410

rather low, but of medium breadth and slope. The sagittal region has a slight median elevation. The temporal regions are flat, and the occipital region is protuberant, with a well-marked inion. The sutures are simple in serration. The sagittal suture shows obliteration beginning dorsally, and the lambdoid suture shows considerable ventral occlusion. There are a few small Wormian bones in the lambdoid suture. There are no parietal foramina, and the mastoid processes are rather small. The brow-ridges are of medium size and divided into median and lateral portions. The facial portion is detached and fragmentary. On the right side is a complete infraorbital suture. The malars are large, but the zygomata show only medium development. The dentition is complete and moderately worn. The teeth are of fair quality, showing a few caries and traces of several alveolar abscesses. The cusp formula of the lower molars is 5–5–4. The mandible is large, with a prominent mental process,

CRANIAL INDICES

Catalogue number Sex	**60380** Male	**60388** Male	**60379** Male	**45651** Male	**60377** Male	**60384** Female	**56669** Female	**60378** Female
Length–Breadth	71.35	72.19	78.09	79.35	(75.81)	79.64	78.70	78.65
Height–Length	75.00	74.87	77.53	81.52	?	85.03	81.07	76.40
Height–Breadth	105.11	103.70	99.28	102.74	?	106.76	103.01	97.14
Cranial Module	157.6	154.00	151.6	160.0	?	147.3	146.3	151.3
Total Facial	85.71	89.19	?	83.57	?	88.71	?	?
Upper Facial	53.74	51.35	?	50.00	?	54.84	?	?
Gnathic	93.69	91.23	?	96.26	?	95.15	99.02	?
Orbital: right	78.89	78.26	?	?	?	81.58	?	?
left	78.89	78.26	?	74.36	?	84.93	97.74	?
Nasal Index	44.83	51.92	?	52.94	?	47.06	50.00	?
Palato-Maxillary	120.69	118.03	?	?	117.24	120.75	111.32	?

a well-marked mylo-hyoid ridge, but small genial tubercles. The ganial angles are everted.

60387, Grave 5. These are fragments of the skull of a middle-aged male. The teeth are well worn. The palate shows a well-developed torus. The fragmentary mandible was large, with prominent mental process and strongly everted gonial angles. The mylo-hyoid ridge and genial tubercles are poorly developed. The fragments show strong muscular attachments. No measurements could be taken, nor were sufficient portions preserved to permit repair of the skull.

60384, Grave 4, Western skeleton. Skeleton of a sub-adult female about eighteen years of age.

The skull is in a good state of preservation. The frontal region is narrow and of medium height and slope. There is a slight median frontal crest. The sagittal region is moderately arched, with a slight postcoronoid depression. The skull is rather narrow. It is subbrachycephalic (69.64), hypsicephalic (85.03), and akrocephalic (106.76). The temporal region is rather flat, and the occipital curve is steep. The sutures are of a simple pattern and have remained open. There are no Wormian bones. The pterions are a narrow H in shape, and there is but one small left parietal foramen. One medium retromastoid foramen is found on each side, and the mastoid processes are small.

The brow-ridges are undeveloped, and there is no nasion depression. The nasal bridge is low, of medium breadth, and concavo-convex. The nasal aperture is of medium breadth, with dull lower borders and a small spine. The orbits are oblong and horizontal, and there are no infraorbital sutures. Suborbital fossae are shallow, malars of medium size, and zygomata small. There is a moderate alveolar prognathism. The dentition is complete, the teeth of excellent quality and but slightly worn. The molar cusp formula is $\frac{4-4-3}{5-5-4}$. Shovel-shaped incisors are present. There is but one caries, and one alveolar abscess. On account of reduction and rotation of the third molars, the palate is elliptical in shape, with a slight torus. The glenoid fossae are of medium depth, with traces of the postglenoid tubercle. The styloids are undeveloped. The middle lacerate foramina are small, but the petrous parts show a moderate depression. The posterior lacerate foramina are large. There are no other features of the skull base of particular note, except that postcondyloid foramina are absent and there are no dehiscences in the floor of the auditory meatus. The mandible is of medium size, but with a rather low and broad ascending ramus and a shallow sigmoid notch.

60381, Grave 2. Fragmentary skull of a young adult female. Although measurements cannot be taken, the subject was certainly dolichocephalic. The frontal region shows medium height, breadth, and slope. The calvaria is narrow in the sagittal region and shows a slight postcoronoid depression. The temporal regions are flat and the occiput is protuberant. The sutures are simple in pattern and obliteration has not begun. There are no Wormian bones, no parietal or retromastoid foramina. The pterions are of the usual H-form. The mastoid processes are small. There is a medium development of the supraorbital ridges, which are divided into median and lateral portions. No depression occurs at nasion. The nasal bridge is broken away. The nasal aperture is of medium breadth, with sharp lower borders and a medium-sized spine. Traces of subnasal grooves were noticed. The orbits approximate to a square form and show slight inclination of their horizontal axes. Malars and zygomata are broken. There seems to have been a moderate degree of alveolar protrusion.

The dentition is complete, and the teeth are but slightly worn. The quality is fair. The dental cusp formula for molars is $\frac{4\text{-}4\text{-}4}{5\text{-}5\text{-}5}$. There are no shovel-shaped incisors. Four alveolar abscesses have left their traces in the dental arch. The palate is parabolic, with a high roof. The glenoid fossae are of medium depth and have no postglenoid processes. Styloids are undeveloped. The skull base is fragmentary, and the vault has suffered considerable post-mortem deformation. The mandible is of medium size and shows poor development of the mylo-hyoid ridge and the genial tubercles.

56669, Unearthed by workmen. This is the calvarium of a young adult female. Its description is very similar to that of No. 60384. It is also subbrachycephalic (78.70), hypsicephalic (81.07), and akrocephalic (103.01). In features of the skull vault it is almost identical with the previously described female skull. The orbits, however, are high and rounded; the suborbital fossae are pronounced and there is marked alveolar prognathism. Most of the teeth have dropped out, but it is evident that the dentition was complete and that the third molars were much reduced. Traces of one alveolar abscess were noted. The palate is parabolic. The base of the skull presents the usual low relief found in the crania of female Indians. There is no accompanying mandible.

60378, Unearthed by workmen. Skeleton of a middle-aged female. The facial portion of the skull is broken away and the mandible is fragmentary. The calvaria is subbrachycephalic (78.65), hypsicephalic (76.40), and metriocephalic (97.14). It is of good size and capacity (1410 cc.). The morphological features are those of an average Indian female, with points of sex distinction well marked.

60385, Grave 4. These are the bones of the "child nearest the mother." Since the milk dentition is complete the child must have been twenty months to three years of age.

60386, Grave 4. These are the bones of the "infant by the side of the other child." In this case also the milk dentition is complete.

The child was then within the limits of age stated in the case of the preceding subject.

60383, Grave 3. Bones of an infant. The first milk molar is erupted but the second is unerupted. The age of the infant was then twelve to twenty-one months.

60382, Grave 10. Bones of a child. The first lower milk molar has erupted, the lower canine is almost erupted, and the second milk molar is unerupted. The age of the child at death was probably between sixteen and twenty-four months. The orbits of this child show somewhat dubious traces of symmetrical osteoporosis. This is a nutritional disease of obscure nature, especially common in crania of Peruvian and Central American Indians. The writer has seen it in ancient Indian crania from the Southwest; but has never before observed it in crania of Eastern Indians.

60389, Grave 9. Skeleton of a child. The milk dentition is complete and shows a certain amount of wear. The child was aged three to five years. Here again the left orbit shows signs of an osteoporitic condition.

Long Bones

The femora of this series display ordinary Indian characteristics and do not merit individual descriptions. The middle shaft section is usually prismatic, the linea aspera is well developed, and there is a marked pilastter. Curvature is medium. Some form of a third trochanter is generally present. Platymeria is pronounced. Torsion of the femoral head is medium to pronounced.

The tibiae have strongly retroverted heads. The external tibial condyle is usually more or less convex. Platycnemia is marked. The shaft form is usually a lateral prism. "Squatting facets" on the anterior lip of the inferior articular surface are usual.

The other long bones present no features of special interest.

The long bones of three male skeletons and three female skeletons were sufficiently preserved to permit their utilization for the calculation of stature. For this purpose the well-known formulae of Pearson have been utilized.[1]

The tibio-femoral index in this group, as in many other Indian groups, is extremely high. Stature calculated on the tibiae, conse-

[1] Pearson, Karl, On the Reconstruction of the Stature of Prehistoric Races, Philosophical Trans. 192, A, 1899, p. 196.

MEASUREMENTS AND INDICES OF LONG BONES

	60380 Male Right	60380 Male Left	60388 Male Right	60388 Male Left	60377 Male Right	60377 Male Left	60384 Female Right	60384 Female Left	60378 Female Right	60378 Female Left	60381 Female Right	60381 Female Left
Femur												
Bicondylar length	460	465	481	485	433	433	?	432	?	?	?	426
Maximum length	463	469	485	489	438	436	?	436	(435)	(446)	?	431
Maximum diameter of Head	46	47	48	48	46	46	42	?	42	43	40	40
Subtrochanteric diameter												
Antero-Posterior	25	26	26	26	25	26	20	?	23	23	19.5	20
Lateral	39	38	40	39.5	34	34	30	?	35	36	31	30
Middle Shaft diameter												
Antero-Posterior	30.5	33	32	33.5	32.5	32	25	?	30	29	26	26
Lateral	28	28	28	30	28	29	22	?	26	26	24	23.5
Middle Index	91.80	84.85	87.50	89.55	86.15	90.63	88.—	?	86.67	89.66	92.31	90.38
Index of Platymeria	64.10	68.42	65.—	65.82	73.53	81.25	66.67	?	65.71	63.89	62.90	66.67
Tibia												
Length minus spine	?	401	406	402	?	?	356	353	383	?	356	356
Middle diameter												
Antero-Posterior	?	30.5	34	36	?	35	26	25	31	?	25.5	26.5
Lateral	?	22	22	22.5	?	22	17	17	21	?	18	18
Middle Index	?	72.13	64.71	62.50	?	62.86	65.38	68.—	67.74	?	70.58	67.92
Diameter at level of nutrient foramen												
Antero-Posterior	?	41	39	41	41	38	32	39	34	?	27	28.5
Lateral	?	23	23	23	26	23	20	18	22	?	20	19
Index of Platycnemia	?	57.50	58.97	56.10	63.41	60.53	62.50	64.29	64.71	?	74.07	66.67
Humerus												
Maximum length	?	?	345	342	?	314	306	304	323	?	311	310
Middle diameter												
Antero-Posterior	?	?	27	27	?	18	15	15	23	?	21	20
Latera	?	?	27	27	?	25	21	21	16	?	15	14
Radius												
Maximum length	?	?	272	?	244	248	?	?	?	?	243	238
Ulna												
Maximum length	?	?	(293)	293	?	?	?	?	?	?	262	?
Humero-Femoral Index	?	?	71.13	69.93	?	72.01	?	69.72	74.25	?	?	72.76
Tibio-Femoral Index	?	86.23	83.71	82.22	?	?	?	80.59	?	?	?	82.59

quently, is somewhat higher than when calculated from the lengths of other long bones. In the present instance, formulae utilizing the lengths of both femur and tibia have been utilized, or, when necessary, the mean stature has been deduced from the results arrived at by using formulae for separate bones.

No. 60380, an extremely dolichocephalic male, must have had a stature in life of about 171.5 cm. On the basis of femora the stature of this subject is 168.5, but the tibia yields a stature of 174.4 cm.

No. 60388, another dolichocephalic male, was about 174.3 cm. tall. Here again the tibia yields too high a stature (175.1 cm.). No. 60377, a mesocephalic male, had a much lower stature, only 163.6 cm., reckoned on the basis of the femur. The tibiae are missing. If these had been present the estimate of stature would have been raised to about 165 cm.

No. 60384, a sub-adult female, had a stature of about 157.5 cm. No. 60378, a rather large female, had a stature of about 161.8 cm. No. 60381, a young adult female, was about 158 cm. in stature.

Pelvis. The pelves show the usual marks of sex differentiation. With the exception of that of No. 60378, they were too fragmentary for the taking of measurements.

Measurements and Indices of Pelvis of No. 60378, Female

	mm.		mm.
Pelvis as a whole		Ossa Innominata	
Breadth Maximum ...	257	Height	
Superior Strait		right	200
Breadth Maximum .	124	left	201
Sagittal diameter ...	115	Breadth	
Distance between		right	148
Ischiatic Spines	(95)	left	?
Height of Sacrum	106	Sacral Index............	116.03
Breadth of Sacrum	123	Index of Right	
Pelvic Index	78.—	Innominate Bone	74.—
Brim Index	92.74		

The brim index of this pelvis is so high that one might judge it to be that of a male, were it not for the morphological features, which are clearly female. The ischiatic notch is broad; the preauricular sulcus is well marked; the subpubic angle is large; and the ascending ramus of the ischium and the symphysis pubis are characteristically female. The condition of the pubic symphysis indicates the ninth phase of Todd's age gradations.

Vertebrae. In general the vertebrae of these skeletons present no features of special interest. Marginal exostoses occur on the vertebrae of No. 60377, a middle-aged male. In the case of 60383, another middle-aged male, the vertebrae seem to be carious. One suspects tuberculosis, but it is scarcely safe to attempt a definite diagnosis.

Summary

In addition to the usual tall dolichocephalic type of Eastern Indian there is present in this series a mesocephalic type due to admixture of a short brachycephalic stock. The evidence of this admixture is to be seen in the shortening of the skull, the increase of breadth across the posterior portions of the parietals, increase of the skull height, shorter face, and broader, lower nose. The measurements of some of the mesocephals and subbrachycephals are such as to make one suspect some occipital deformation. This, however, is not apparent from the contours of the occipital bones. In the short series from Winthrop this mixed type actually predominates.

PAPERS

OF THE

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AND ETHNOLOGY, HARVARD UNIVERSITY

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TRANSLATED AND EDITED, WITH AN
INTRODUCTION AND NOTES

BY

ZELIA NUTTALL

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NOTE

The remarkable acumen of the Spanish authorities in sending out a questionnaire to many of the settlements throughout the Spanish domain in America is amply justified by the wealth of material collected by this means. The replies to this list of questions returned by the various towns are all important but special interest centers on that sent by San Juan Teotihuacan on account of the famous ruins at that site.

Mrs. Nuttall early discovered the great importance of this manuscript and has kindly translated it for the present paper.

The Museum is greatly indebted to Clarence L. Hay, Esqr., for its publication.

Charles C. Willoughby, *Director*.

Cambridge, Massachusetts,
February 8, 1926.

LIST OF ILLUSTRATIONS

PLATES

FIGURES

INTRODUCTION

In 1900, Señor Don Pedro Torres Lanzas, the distinguished Director of the Archivo de Indias in Seville, in Volume I of his valuable Inventory of the Plans and Maps contained in the Archives, published the title of the "Map of the towns of Acolman, San Juan Teotihuacan, Tequizistlan and adjoining towns by the Corregidor Don Francisco de Castañeda, accompanied by a descriptive *Relación* [dated 1580], of each of said towns, made in compliance with His Majesty's Instructions." [1]

Separated from its *Relación* for years, the Map was, and still may be, exhibited in one of the treasure filled show-cases of the Archivo. It thus came about that, in 1911, on registering the contents of a "Legajo" attractively labelled "Indiferente General," I came across the *Relación* by mere chance, and after reading it with intense interest, copied it forthwith, as a document of utmost importance that should be generally known.

I had not seen the Torres Lanzas Inventory and was unaware at the time that, in 1905, Señor Francisco del Paso y Troncoso had actually published the *Relación* with the Map, in Volume VI of his "Papeles de Nueva España," etc.;[2] for this, like others of his important and valuable publications, was and is, unfortunately, practically unobtainable and inaccessible to students.

In the monumental work on the "Population of the Valley of Teotihuacan," recently issued by Señor Manuel Gamio,[3] the Map is reproduced, but the *Relación*, while referred to, is not described

[1] See "Relacion descriptiva de los Mapas, planos, etc., de Mexico y Floridas existentes en el Archivo General de Indias, por Pedro Torres Lanzas." Sevilla, 1900. Tomo I, p. 26. This document is registered in the Archivo General de Indias, Sevilla, as follows: Indiferente General — Descripciones poblaciones y derroteras de viajes. Nueva España. Años 1521–1818. Estante 145 — Cajón 7 — Legajo 6.

The text of the questionnaire is translated from the "Memoria" published in "Relaciones de Yucatán." Colección de Documentos Inéditos . . . publicada por la Real Academia de la Historia, Segunda Serie, Tomo XI.

[2] "Papeles de Nueva España publicados de orden y con fondos del Gobierno Mexicana. Segunda Serie. Geografía y Estadística. Tomo VI. Relaciones Geográficas de la Diocesis de Mexico. Manuscritos de la Real Academia de la Historia de Madrid y del Archivo de Indias en Sevilla. Años 1579–1582." Madrid, 1905. Text, pp. 209–230.

[3] "La Población del Valle de Teotihuacan." Secretaría de Agricultura y Fomento. Dirección de Antropología. Mexico, 1922.

as a source of invaluable and authentic information, nor is it deservedly utilized and recorded.

It therefore seems opportune that a publication be made, in English, and *in extenso,* of the *Relación,* for the benefit of Americanists. This document is one of the many that were drawn up and sent from Mexico to Spain in obedience to a remarkable decree, dated May 25, 1577, issued by King Philip II and distributed broadcast throughout his New World possessions. This decree reads:

"Instructions and memorandum for the drawing up of the reports which are to be made for the 'Description of the Indies' His Majesty is having made, to facilitate the good government and ennoblement of the same.

"*Firstly:* The governors, corregidors, or mayors to whom the Viceroys or Audiences or other government officials and administrators send these printed instructions and memorandum are first of all to make a list and memorial of the towns inhabited by Spaniards or by Indians within their jurisdictions, in which only the names of these towns are to be entered, written clearly and legibly. This is to be immediately sent to said government officials so that it can be returned to His Majesty and the Council of the Indies jointly with the reports drawn up in each town.

"Said printed instructions and memorandum are to be distributed throughout all towns of Spaniards and Indians in each jurisdiction in which there are Spaniards, sending them to the Councils, or, if these are lacking, to the parish priests or to the monks in charge of religious instruction, with direct orders to the councils or a recommendation from His Majesty to the priests and monks, that within a short time they answer and fulfil their obligations.

"The reports made are to be sent to the above officials, with the printed instructions, so that, as they go on receiving them they can redistribute them to other towns to which none have been previously sent.

"In the towns and cities where the governors or mayors or other officials reside, these are either to write the reports according to the instructions, or to have this done by persons with a knowledge of the affairs of the country. The persons charged with the drawing up of the report of each town are to give answers to the questions in the memorandum and observe the following order and form.

"*Firstly:* On a separate sheet, as a superscription to their report, they are to write the day, month and year dates, with the name of the person or persons who participated in making it; also the name of the governor or other person who sent them the said instructions.

"After carefully reading each paragraph of the memorandum, they are to write down separately what they have to say, answering each one of the questions it contains, one after the other. Those questions to which they have nothing to answer are to be omitted without comment, passing on to those that follow, until all are read. The answers given are to be short and clear. What is certain is to be given as such, what is not is to be recorded as doubtful, so that the reports may be exact and in strict conformity to the instructions and memorandum."

The latter consists of a series of most carefully formulated, penetrating and comprehensive inquiries, and constitutes a "questionnaire" so remarkable for its acumen that I have adopted the plan of presenting the questions in the order established by the royal questionnaire and, after each one, in succession, the answers to it sent in from the four towns.

The combined evidence is thus presented in a concentrated and more interesting form, that will facilitate the survey and study of the fresh data presented concerning one of the most important archaeological regions in America.

The *Relación* was supplemented by the interesting map that is reproduced as Plate 1. The reproduction in Plate 2 is from a photograph of the same district containing the four towns, as represented in the famous map of Mexico and its surroundings made by the cosmographer of King Philip II, Alonso de Santa Cruz, about 1570.

As the main purpose of this publication is that of placing the valuable record within the reach of students, I have confined myself in my notes to drawing attention to certain important points and elucidating a few statements that are obscure or misleading.

Descriptions of the towns of Tequizistlan, Tepechpan, Acolman, and San Juan Teotihuacan, and their dependencies, were composed by the illustrious Señor Francisco de Castañeda, the Corregidor of said towns, for His Majesty, in obedience to the royal instructions transmitted to him by the illustrious Señor Gordian Cassasano, accountant and administrator of the Royal Revenue of this New Spain.

The description of each town is signed by those persons present who could sign.

A list of said towns and those subordinate to them accompanies each description.

The towns included in the circuit and jurisdiction of Tequizistlan are as follows:

Firstly: Tequizistlan, chief town, with its subordinates Totolzingo and Acaltecoya.

Secondly: Tepechpan, chief town, with its subordinates San Miguel Atlanmaxac, Santiago Saqualuca, Santa Ana Tlachahualco, San Francisco Temazcalapa, San Matheo Teopancalca, San Pedro Tulamiguacan, San Xriptoual Culhuacazingo, Santa Maria Maquixco, Sant Jhoan Tlacalco, San Bartolome Atocpan, San Xeronimo Chiapa, Santa Maria Suchitepec, its subordinates, and San Juan Cuyoa.

Thirdly: Acolman, the capital, with its subordinates Santiago Atla, San Miguel Jumetla, San Agustin Tonala, los Tres Reyes Yzquitlan, Santa Maria Chiapa, San Matheo Tuchatlauco, San Lucas Tlamazingo, San Juan Tepehuizco, Santiago Nopaltepec, San Juan Tlaxinca, San Martin Huiznahuac, San Felipe Sacatepec, San Tomas Atlauco, San Matheo Tezcacohuac, Santa Maria Atenpa, San Marcos Quacyocan, San Pedro Tepetitlan, San Antonio Huiztonco, Santa Maria Tlatecpa, San Bartolome Quauhtlapecco, San Juan Chicnahuatecapa, San Martin Aticpac, San Niculas Tenextlacotla, Santa Maria Astatonacazco, Santa Maria Atenpa, Santa Maria Saguala, and San Juan Atlatongo.

Fourthly: San Juan Teotihuacan, with its subordinates San Lorenço Atezcapa, San Miguel Tlotezcac, San Matheo Tenango, San Sebastian Chimalpan, Santa Maria Coatlan, San Francisco Maçatlan, San Martin Teacal, San Pedró Tlaxican, Santiago Tolman, Sant Andres Oztocpachocan, Los Reyes Aticpac, San Antonio Tlaxomolco, San Agustin Ohuayocan, San Pedro Ocotitlan, San Miguel Tlaguac, San Luis Xiuhquemecan and Juan Tlaylotlacan.

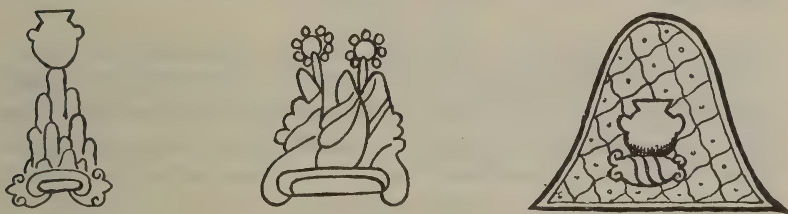
THE QUESTIONS AND ANSWERS THERETO

QUESTION I

In the towns with Spanish inhabitants the name of the district or province is to be stated, also the meaning of the name and the reason it is so named.

Tequizistlan

The town of Tequizistlan is the capital of the jurisdiction. It is in the district of Texcoco, and was in ancient times an independent town that rendered allegiance to its natural lords until Neza-



a b c

Figure 1. Place-names of Texcoco.

hualcoyotzin, lord of Texcoco, became an ally and confederate of Montezuma, lord of Mexico, and with tyranny subjugated said district, incorporating it into Texcoco and Mexico. The natives were unable to explain the meaning of the name Texcoco.[1]

[1] Evidence that the primitive town of Texcoco, like the residence and hill garden of Nezahualcoyotl, was situated in or among the rocky foot-hills is furnished by the hieroglyph of the town, of which several variants are recorded in the native picture-writings and are retained in the arms of the town granted by Philip II and still in use.

Its main element is a rocky hill, "Texcalli," that conveys the first syllable of the name. In the "Code en Croix" of the Aubin-Goupil Collection, the rocky nature of the hill is graphically rendered and this is surmounted by an earthen pot with two handles (a Comitl) that conveys the syllable "co"—an affix that signifies "in" (Fig. 1,*a*).

In the Codex Mendoza, the hill is ingeniously formed by three signs for "Tetl," stone, forming three peaks, between which—"co," = in—are two conventionalized drawings of a popular medicinal rock-plant (a Senecio), either of the names of which, "Texcotli" or "Texcapatli," conveys the first two syllables of the name, while "Tetl" acts as a determinative (Fig. 1,*b*).

A third variant occurs in the "Histoire de la Nation Chichimèque" (Catalogue Raisonné de la Collection Goupil, E. Boban. Atlas. Planches 2 and 3), where, in a conical hill (covered with a design consisting of diagonals and dots), the pot "Comitl" is figured above the sign for stone, "Tetl." In this case two duplications of sound occur, that is: "Texcalli" or hill, and "Tetl" or stone. The duplication of "co" was obtained by placing the "Comitl" in (co) the hill (Fig. 1,*c*). Of the three examples given, this is the only one in which the vowel "co" is duplicated and the full name "Texcoco" is conveyed. In the others, it was evidently considered sufficient to record "Texco" only.

For the etymology of the names of the other towns dealt with in this document, see the answers to Question XIII farther on.

Tepechpan

The town of Tepechpan and its dependencies are held by Geronimo de Baessa, citizen of Mexico City. It is in the province of Texcoco and was an independent town until Nezahualcoyotzin, lord of Texcoco, tyrannized over it and made it a subject of Texcoco.

Acolman

Acolman is in the district of Texcoco and was an independent town where the Chichimecs had their metropolis until Nezahualcoyotzin, lord of Texcoco, tyrannized over them, as will be told farther on.

Teotihuacan

The town of San Juan is in the district of Texcoco. In ancient times it was the capital of a province because the surrounding towns, which were Otumba, Tepeapulco, Tlaquilpa and others, acknowledged it as such in heathen times, until Nezahualcoyotzin, lord of Texcoco, conquered them in war and tyrannized over them.[1]

QUESTION II

Who was the discoverer and conqueror of said province and by whose order or mandate was it discovered? Give the year of its discovery and conquest and all that can be readily learnt about it.

Tequizistlan

As it is publicly known that it was Don Hernan Cortés, the Marques del Valle, who discovered New Spain in 1519, reference is here made to the description which will be written in the City of Mexico.

Tepechpan

The discovery of said town in New Spain was made in 1519 by the Marques del Valle, Hernan Cortés, as is referred to in the description of the town of Tequizistlan.

[1] The important facts established by the above answers to Question I are that Tequizistlan and Tepechpan were "independent towns," that Acolman was "the Chichimec metropolis," and that Teotihuacan was "the capital of a province" until all four towns were conquered by the allied lords of Mexico and Texcoco. The date of this conquest, etc., will be given in the note pertaining to the answers given to Question XIV.

Acolman

As is publicly known, the discoverer of this town and of New Spain was Hernan Cortés, the Marques del Valle. The order and mandate and the year of its discovery are not set down here because in the description to be made in the City of Mexico these will be stated by the person in charge.

Teotihuacan

The Marques del Valle was the discoverer of this land.

QUESTION III

State in general the climate and quality of said province or district; whether it is cold or hot, dry or damp, with much water or little and at what season there is more or less; and the prevailing winds, whether violent and from what quarter and at what season of the year.

Tequizistlan

Its temperature is cold and damp on account of its being situated near the great lagoon in the midst of canals. The rains fall generally from May until the end of September. The winds blow from the South from January to the end of March in which month it blows with such violence that it causes many natives to suffer dangerously from headaches. From April onward, until the rains begin, the North wind generally blows with great strength at sunset. This does less harm to the natives than the South wind.

Tepechpan

The temperature and quality of the climate of the capital Tepechpan is cold and damp, for the greater part of it lies low among canals. All of its dependencies are in a cold, dry region. Rains fall generally from the first of May to the end of September. South winds are prevalent from Christmas until the end of March and are very violent during the whole of this month, causing illness among the natives. From April onwards the North wind blows and is less harmful, for in the day time it is temperate. All night it blows violently but as at this time the natives have retired into their homes it does not harm them.

Acolman

The capital town of Acolman is cold and damp on account of being situated among canals and of having bad night dews. Its dependencies are in a cold region and lack water because the only water they have is rain water in basins or pools. From the middle of December until the end of March the South wind gives the natives headaches and pains in their bodies. In March it blows with great force. When the rains begin, the North wind blows and is unhealthy for the natives even if it blows temperately.

Teotihuacan

The region in which said town and its dependencies lie, is cold, excepting its capital which is cold and damp on account of being situated among canals and fountains all proceeding from flowing springs. In winter from Christmas to March the South wind blows, with greater violence in March. It is unhealthful for the natives. From March to the end of October the North wind blows but does no harm to the natives because it is tempered.

QUESTION IV

State whether the country is level, rough, flat or mountainous; with many or few rivers and fountains, with abundance or scarcity of water; whether fertile or lacking in pasture; with an abundance or scarcity of fruits and sustenance.

Tequizistlan

Its entire district consists of a level plain open on all sides without any trees. Towards the East there is a high range of mountains. It lacks wood. The natives drink water from wells. It lacks fodder but yields an abundance of maize and beans, cactus fruits, cherries and agaves, of which the natives make good use.

Tepechpan

The land is flat and in Tepechpan and its dependencies there are very few trees. All the natives drink stored rain water although the river named San Juan passes through the town.

ACOLMAN

The capital Acolman is situated in a plain at the foot of a mound. It is level and has no fountains. A river called "de San Juan" runs by said town and is divided into three canals with which they irrigate a great piece of land nearly a league long and half a league wide. It is prolific in fodder and sustenance.

TEOTIHUACAN

The capital, San Juan, and all its subordinate towns lie in a plain and the farthest of the latter is situated at a distance of two leagues from the capital. Towards the North, a league distant, is a great mountain which the natives name Tenan, which in Spanish means "mother," because many small hills issue from it.[1]

[1] The second half of this name, "nan," is an abbreviation of "Nantli," mother, while the first, "te," is a contraction of "Tetl," stone; thus the ancient Nahuatl name of the mountain signified "Stone Mother," or "Mother of Stone." The native explanation that the mountain was so named "because many small hills issue from it" and because "it had given birth to many other mountains" (see answer to Question XXI) is shown to be strikingly appropriate by the report on the geology of the mountain recently published by Señor Ezequiel Ordoñez, the distinguished ex-Director of the Geographical Institute of Mexico, in the monumental work already cited on the Valley of Teotihuacan issued by the Department of Anthropology.

Señor Ordoñez writes that the mountain, an extinct volcano, "does not now show its crater which had once vomited such great volumes of lava and loose stones, doubtlessly because the residue of the last lava flow had consolidated and obstructed its mouth. Before becoming extinct, however, it gave birth to a number of small subordinate volcanoes which, like parasite volcanoes, are scattered over its eastern, northern, and western slopes, and look very fresh." From the foregoing, it may be inferred that the native name "Mother of Stone" dated from a period when the dying volcano gave periodical birth to the small craters, possibly in comparatively recent times. Compare note 1 on p. 74.

Additional light is thrown on the ancient association of the mountain with the production of stone by other facts recorded by Señor Ordoñez and also reported upon by the energetic and painstaking young geologist, Señor Diaz Lozano, in the same monumental work. Both geologists point out, as a characteristic of the now extinct volcano, the enormous quantities of loose stones and volcanic bombs which it cast forth with great force and scattered over the adjacent plains. Señor Ordoñez states that the first inhabitants of the Valley of Teotihuacan must have found it thickly strewn with loose stones which would have constituted an inducement for them to settle there and build a city. Close by, moreover, was an inexhaustible supply of loose basaltic stones of a portable size, for between the base of the "Mother of Stone" and the site of the ancient metropolis there are vast areas covered with basaltic agglomerations which can easily be detached and there are also great caves or pockets entirely filled with loose stones. One of these caves is two hundred and ten feet long, sixty feet wide and forty-five feet high — others are three hundred feet long and nine feet deep. Besides this loose portable material the mountain furnished different kinds of basalt which were shaped and worked at a later period, a peculiar basalt whose structure furnished very compact and hard, thin, flat stone slabs which the primitive builders used as flags for flooring, in making drains and as supports for cornices. Pointed fragments of this hard stone were also employed as chisels by the ancient sculptors; besides all this valuable building material the same mountain had produced the immense quantity of the very light, porous loose fragments of lava, of various colors, which are so extensively employed by the ancient constructors. The entire appropriateness of the name bestowed upon the prolific mountain by the ancient builders is therefore amply demonstrated, as well as its

Another hill, medium sized, shelters the southeastern portion of the plain. In the territory of the subordinate towns there is a lack of water and the natives drink stored rain water. In the capital there is an abundance of water and many springs close together that feed a large river on which the natives have a mill. The water of said river irrigates two leagues of land, which is the whole length of its course. It passes by the towns of Acolman, Tepechpan, Tequizistlan, and the boundary of Texcoco, and empties itself into the lagoon. This region yields an abundance of fodder and food supplies.

QUESTION V

State whether the district is inhabited by many or few Indians and whether in former times it had a greater or lesser population; the causes for the increase or diminution and whether the inhabitants live in regular towns permanently or not.

State also what is the character and condition of their intelligence, inclinations and modes of life; also whether different languages are spoken throughout the whole province or whether they have one which is spoken by all.

Tequizistlan

In ancient times, before the Conquest, it was densely populated and had more than four thousand tribute-paying inhabitants. After the Conquest many died from an illness like itch or mange all over the body. Since then they have always had illnesses. The Indians think that these have increased because they now have more luxury than in former times and because, before the

unquestionable antiquity; for all indications point to the name having been invented at a remote period when small craters were still being formed and when the vast agglomerations of portable building material had been discovered and exploited by the founders of the great metropolis, that owed its existence to the vast amount of portable stones so conveniently at hand.

The ancient name "Tenan" is quite unknown to the present inhabitants of the region, as I found on making many inquiries. Nor is the old name recorded in the recent publication mentioned above.

In a document dated 1608, published in this same work (Part III, p. 573), the name of the mountain is given as "Temiztepetl," called "Cerro Gordo," and the latter Spanish name is the only one by which it is known by the natives nowadays. The fact that the ancient name "Tenan," which appears to hark back to the nebulous period when Teotihuacan was founded, is in the highly developed and ancient Nahuatl tongue furnishes a valuable indication that the occupation of the Valley by Toltecs, a Nahuatl-speaking race, long ante-dated the arrival of the Aztecs in historical times.

Conquest, they used to go naked and sleep on the ground and eat cactus leaves, cooked agave leaves and other plants yielding scant nourishment. Now they live well, eat delicate viands, baked bread, chicken, and beef and mutton, and wear clothes and sleep high [that is, in beds] covered at night with blankets. Any excess makes them ill, especially the drinking of *pulque*, which is general amongst them and is drunk from their childhood. Previous to the Conquest, when they did not drink nor were permitted to do so and were punished for drinking, they died old. Nowadays they do not live as long.[1] This town has no streets nor have its dependencies, which are scattered about. The inhabitants are of medium intelligence. Their inclination is toward cultivating their lands excepting in one dependency which lies on the shore of the lagoon, in which the natives live on fishing and catching ducks and other birds with nets. They speak the Nahuatl language.

Tepechpan

At the present time this town and its dependencies have nine hundred and fifty tribute payers. In former times, and a short time before the Conquest, it was densely populated. The inhabitants have dwindled on account of the diseases they have had, which, according to the native belief, proceeded from their having less work and more luxury than before the Conquest, and also from the drinking of *pulque* and because at present the natives eat fowl and other birds whereas formerly they ate cactus leaves and the pulpy agave leaves and other herbs of little sustenance. The town is not a regular but a scattered one. The foremost or chief natives are of medium understanding and the rest are rude and dull. They are inclined to cultivate the land and maintain themselves by this exclusively. The Nahuatl tongue is commonly spoken, with the exception of some few natives who speak the Otomi tongue.

Acolman

In past times it had many inhabitants. The natives were not able to tell us anything more certain than that in every house there lived six or seven married couples, besides unmarried youths. They died of the illnesses which spread amongst them. At the

[1] For interesting evidence concerning the relative health and longevity of the natives before and after the Conquest, see the answers to Question XV and notes thereto.

present day according to the list of tribute payers, it has nineteen hundred of these. It is built without order and is not a regular town. Its inhabitants are well disposed although dull of understanding. They live by cultivating the soil. The language they generally use is the Nahuatl. A few speak Otomi.

Teotihuacan

The natives say that in ancient times this town was thickly populated by a great number of inhabitants. At present it has besides the ordinary population, according to appraisement, one thousand and six hundred payers of tribute. The natives say that many of them died during an epidemic which occurred a year before the discovery of New Spain. The town was not founded on a regular plan, but consists of a number of scattered houses. The inhabitants of said town are a polished people of a good understanding [1] who always live on the produce of their land. They speak Nahuatl generally, but a very few of them speak the Otomi and Popoluca tongues.

QUESTION VI

State the latitude in which these towns of Spaniards lie if this has been taken or if known or if there is any one who knows how to take it. State on what days of the year the sun does not cast a shadow at noon.

Tequizistlan

This town lies in a straight line directly north of the City of Mexico at a distance of three leagues, therefore its latitude would be ten minutes higher than that of said city. In the middle of May and at the end of June the sun casts no shadow at noon.

Tepechpan

The latitude of the town of Tepechpan is about twelve minutes higher than the City of Mexico as its distance is about three

[1] Attention is drawn to the significant fact that whereas the inhabitants of Teotihuacan are described as "a polished people of a good understanding," those of two of the other towns are entered as "of medium intelligence," and those of Acolman as "well disposed although dull of understanding." The higher degree of culture was evidently a survival from the time when Teotihuacan was the capital of a province, the residence of the ruling intellectual class and a great religious centre.

leagues to the North of said City. In the middle of May and at the end of June the sun casts no shadow because the sun is at the zenith and shadows are under one's feet and do not incline in any direction.

Acolman

Acolman lies due north from the City of Mexico at a distance of a little more than three leagues; the difference in the latitude is nine minutes. In the middle of May and almost at the end of June the sun casts no shadow at noon and the shadow is underfoot.

Teotihuacan

On account of the lack of the necessary instrument it was not possible to determine the latitude of the town, but, judging by that of the City of Mexico, it must be a little over twenty degrees. At the end of the month of May and in June the sun casts no shadow at noon.[1]

QUESTION VII[2]

State the distance in leagues between each city or town occupied by Spaniards and the city in which resides the Audiencia to whose jurisdiction it belongs or the residence of the governor to whom it is subject — also the direction in which said cities and towns lie from each other.

QUESTION VIII

Give also the distance in leagues between each city or town occupied by Spaniards and those of the adjoining district, stating in what direction they lie; whether the leagues are long or short, the country level or broken and mountainous; whether the roads are straight or winding and good or bad for travel.

QUESTION IX

State the name and surname that every city or town has or had and the reason, if known, why they were so named; also who was

[1] In the Valley of Mexico and at Teotihuacan the sun is in the zenith twice a year: on May 17th at about 11.33 A.M., on its journey northward, and on July 26th, at about 11.43 A.M., on its return southward, at legal time (that is, the local mean time of the 105th Meridian).

[2] The following six questions are grouped together, and others will be similarly treated when the answers to them sent in from the four towns are more or less incomplete or are furnished by one town and not by another.

their founder, who named them, and by whose order or mandate he made the settlement; the year of its foundation and the number of inhabitants at that and at the present time.

QUESTION X

State the situation of said town, if it lies high or low or in a plain, and give a plan or colored drawing of the streets, squares and other places, the monasteries to be marked, which can be easily sketched on paper, as well as can be done. It is to be noted which parts of the town face North and South.

QUESTION XI

In the case of Indian towns it is only to be stated how far they are from the capital, in what district and jurisdiction they lie, and which is the nearest centre for the teaching of religious doctrine. The names of all of the chief towns in its jurisdiction are to be given as well as those of their respective dependencies.

QUESTION XII

State also the distance between the other towns of Indians or Spaniards that surround it and the directions in which they lie and whether the leagues are long or short and the roads level or straight or mountainous and winding.

TEQUIZISTLAN[1]

The distance between the town of Tequizistlan and the City of Mexico, where the Royal Audiencia resides, is of five leagues of road, three running from North to South and two from East to West. The town lies at the Northeast of the City of Mexico. It lies in a low plain, among canals, very close to the lagoon. It is

[1] Señor Troncoso has drawn attention to the fact that in a document dating from the middle of the sixteenth century, the name of this town is given as "Tecciztlan" (op. cit., Vol. VI, p. 226 note). This is confirmed by the use of the great marine conch shell—"Tecciztli"—as the hieroglyph to designate the town in the Alonso de Santa Cruz map, although the Spanish rendering of the name as "Tequizistlan," is written alongside. (See Plate 2, upper left corner.) The native informants were evidently aware that the local name was derived from some sort of shell. The gratuitous and plausible explanation they volunteered, however, about the name having originated from the abundance of small fresh-water shells found in the canals is obviously wrong, and may have been inspired by the wish to appear ignorant of the name, even, of the marine conch shell that was so intimately associated with the cult of the moon and the water gods in their ancient, forbidden and persecuted religion.

the capital of the district of the Corregidor and is a league distant from Acolman, the centre for the teaching of religious doctrine. Its dependencies are Totoltzinco and Acaltecoya. It lies to the Northeast of the City of Mexico, separated from it by a distance of five leagues of straight and level road running from North to South for three leagues and from East to West for two leagues. A straight and level road leads to the City of Texcoco which lies to the Southeast at a distance of two leagues. These leagues are medium ones.

Tepechpan

The town of Tepechpan is at a distance of five leagues from the City of Mexico where the Audiencia and Royal Chancery reside and is separated by a level road which runs directly from North to South for three leagues and two from East to West. It lies to the Northeast of the City of Mexico. The town is situated in a plain on the southern slope of a small hill. The plain is open to all sides. It has, to the Northwest, a small mountain which shelters it, and at the North the hill at whose base it lies protects it also somewhat. It is exposed towards the East. It belongs to the jurisdiction of Tequizistlan and is at a distance of a quarter of a league from said town and from Acolman where the monks who teach the Doctrine reside. Within three quarters of a league are its dependencies, Santiago Zaqualuca, San Miguel Atlanmaxac, Santa Ana Tlachahualco, San Francisco Temazcalapa, San Matheo Teopancalco, San Pedro Tulamihuacan, San Cristobal Culhuacazingo, Santa Maria Maquiteco, San Juan Teacalco, San Bartolome Atocpan, San Geronimo Chiapa and Santa Maria Suchitepec.

The town Tepechpan is at a distance from the City of Mexico of five medium leagues by level road, which runs for three leagues from North to South and two from East to West. It lies Northeast of the City of Mexico.

At the Southwest of the town of Tepechpan lies the town of Texcoco two long leagues distant by a straight and level road. At its South lies the town of Tequizistlan, a quarter of a league distant by a straight road and at its North the town of Acolman, its religious centre, three quarters of a league distant by a straight, level road. Towards the West it has the town and district of Chiconauhtla, two short leagues distant by a straight and level road.

ACOLMAN

The town of Acolman falls under the jurisdiction of the City of Mexico where the Royal Audiencia resides, at a distance of five long leagues of level road, three and a half of which run almost due North to South and a league and a half to the Northeast. At its Southwest lies the town of Texcoco at a distance of two and a half leagues of straight, level road. It belongs to the jurisdiction of the district of Tequizistlan and is the chief seat of religious instruction. Its dependencies are San Pedro Tepetitlan, San Antonio Huiztonco, San Miguel Jumetla, Santa Maria Tlatecpa, Sant Ana Atenpa, San Bartolome Quauhtlapeco, San Juan Chiconauhtecapa, Santiago Atla, Tres Reyes Yzquitlan, San Agustin Aticpac, San Martin Tonala, San Niculas Tenextlacotla, Santa Maria Ostonocazca, San Matheo Tezcacohuac, Santo Tomas Atlauhco, San Marcos Quauhyoca, San Felipe Sacatepec, San Martin Huiznahuac, Santa Maria Atenpa, San Juan Tlaxicaya, Santiago Nopaltepec, San Matheo Tochatlauco, San Lucas Tlamazingo, Santa Maria Saquala, Santa Maria Chiapan, San Juan Tepehuizco and San Juan Atlatonco.

To its South it has the town of Tepechpan, three quarters of a league distant; to the North-northeast the town of San Juan Teotihuacan, one league distant; to the Southwest the town of Texcoco, nearly two and a half leagues distant; to the West the town and district of Chiconauhtla, a long league and a half distant.

TEOTIHUACAN

The town of San Juan Teotihuacan lies to the Northeast of the City of Mexico where the Royal Audiencia resides, at a distance of six long leagues of level country. The said town of San Juan is separated from the city of Texcoco by three long leagues of straight road and level country. Its distance from Acolman is one league; from Tequizistlan two leagues both lying almost directly South. Tequizistlan is the capital of the Corregimiento.

Its subordinate towns are: San Lorenzo Atezcapa, San Miguel Tlŏtezcac, San Matheo Tenango, San Sebastian Chimalpan, Santa Maria Aguatlan, San Francisco Maçatlan, San Pedro Tlaguican, San Martin Teacal, Santiago Tolman, San Andres Oztolpachuncan (*sic*), Los Reyes Aticpac, San Antonio Tlajomulco, San Agustin

Ohuayucan, San Pedro Ocotitlan, San Miguel Tlalguac, San Luis Xiuhquemeccan, San Juan Evangelista Tlaylotlacan. Its distance from Otumba is two leagues to the Northeast by a straight road. The town of Tepetlauztuc lies to the Southwest at a distance of two and a half leagues of level ground.

QUESTION XIII

State what the name of the Indian town means; why it was so named; what there is to know about it and what its name is in the language which the native inhabitants actually speak.

Tequizistlan

Tequizistlan means "place where shells abound" and, according to the natives, it is so called because there are many shells in the canals of said town. The sole language they speak is the Nahuatl.

Tepechpan [1]

Tepechpan in the Indian language means "a town set on a large rock" and is named thus because it was founded near a rocky hill. The language spoken by the natives of the chief town and its dependencies is the Nahuatl, with the exception that some few of them speak Otomi.

Acolman [2]

Acolman in the Nahuatl language means "shoulder and arm." The Indians could give no reason why it was thus named. The language they generally speak is the Nahuatl; a few speak Otomi.

[1] "Tepexitl"—a large rock; "Pan"—upon. In the original document the name of this town is written "Tepexpan"— a spelling that is more correct than "Tepechpan," now in use.

[2] The name of the town of Acolman, expressed by a rebus consisting of a shoulder and arm combined with the sign for water, is an interesting specimen of the native picture writing. The shoulder — "Acolli" — conveys the first two syllables of the name and the sign for water — "Atl" — serves as a determinative by duplicating the vowel "a." The hand — "Maitl" — furnishes the syllable "ma," and thus "Acol-ma" was conveyed, this being the ancient name, as can be seen in the Plan (Plate 1) where it is spelt "Aculma," the u and o being interchangeable in the Nahuatl tongue. The fact that the same hieroglyph served also to express the tribal name "Acolhua" and the name of the province "Acolhuacan" is revealed by its use in combination with the sign for Texcoco in the Codex Mendoza, the Codex Osuna, and in the arms of the town conferred upon it by Philip II.

This combination was probably assumed after the Conquest of Acolman, the ancient metropolis of Acolhuacan, by Nezahualcoyotl, when Texcoco became the capital of the province, and the name Acolhuacan was applied to the whole territory subjected to the Texcocan rulers.

In the famous map of Alonso de Santa Cruz, the familiar rebus consisting of an arm and water designates the town of Acolman (see centre of Plate 2 and compare with Fig. 2, from

Teotihuacan

In the language of the Indians the name of the town of San Juan is Teotihuacan, meaning "temple of gods," because in this town there was the oracle where the Indians of Mexico and those of all other surrounding towns idolatrized.[1]

QUESTION XIV

State to whom the Indians belonged in heathen times and what dominion was exercised over them by their lords; what tribute they paid and the form of worship, rites and customs they had, good or bad.[2]

Codex Mexicanus, Collection Goupil-Aubin Planche, 24, op. cit.) the name of which is, however, not written also in Spanish characters as in the case of the majority of other places. It was probably for this reason, and for the misleading error of the map-maker, who wrote the name "Tequizistlan" close by (in the wrong place and for the second time) that it was overlooked by Señor Arreola in the recent Mexican government publication already cited. On page 370 of Tomo I, Volume II, he actually affirms: "Alonso de Santa Cruz does not even register the town of Acolman." ("Alonso de Santa Cruz no registro siquiera el pueblo de Acolman.")

It is interesting to note that in 1697 Gemelli Carreri wrote that he had visited "the town of Acolman or Aculma," which shows that both pronunciations were still in use at that time.

The fact that, in the Codex Mendoza, the identical sign composed by an arm and water is used to designate the town of "Coliman" — Colima — is interpreted by Orozco y Berra and Peñafiel, in *Nombres Geográficos*, as implying that this locality, near the Pacific Coast, was conquered by the Acolhuas. They were evidently not aware that Ixtlilxochitl, the native historian whose statements are of great weight, having been approved of by the six most learned and aged caciques of his time, relates that the Acolhuas "were from beyond the provinces of Michoacan," and that in the year One Flint (1063 A.D.) three Acolhua lords, whose names he gives, "accompanied by many vassals, among them the nation of Otomis, having heard of the greatness of Xolotl, the Chichimec lord and leader, of his having seized all the country and that he was colonizing it, came to offer him obedience and ask him for lands where they could colonize. He was much pleased to see them, for they were a civil people, well governed, and giving them lands for colonizing, he also gave two of them daughters of his in marriage; to the principal lord named Acolhua he gave his oldest daughter, and the town of Atzcapotzalco as the capital of his state, with more lands and provinces for his vassals; to the second, with a daughter, the town of Xaltocan (on an island in the lake of Xaltocan); and to the third 'Acolhuatitlan Acolhuacan.' In this way he obliged them, telling them that they only needed to recognize him as their lord and sovereign, and need not pay him any tribute whatsoever." (See Obras Historicas de . . . Ixtlilxochitl, ed. Chavero, Mexico, 1891, Tomo I, p. 94, also p. 268 and Tomo II, p. 40.) Archaeological evidence, obtained in recent years, strikingly confirms the truth of the above history, for a remarkable similarity exists between the type of the clay figurines I and several fellow-archaeologists have found near Atzcapotzalco (in my case at a depth of 16 feet under a gravel-bed) and those unearthed in the present states of Michoacan and Colima. Both are characterized by the same type of long, narrow faces and square brows, etc., the clay being, in both cases, of a fine, light-colored variety.

[1] Without entering here into what would be a fruitless discussion of the many different etymologies of the name that have been published from time to time, the newest being contained in the recent publication of the Mexican Government, attention is drawn to the interesting explanation given here that Teotihuacan owed its name and designation as a "temple of gods" *to a famous oracle that was there.* Further mention of this oracle will be found in the answer to Question XIV.

[2] Attention is drawn here to the curious fact that in the following answers from the town of Tequizistlan it is stated that "they adored the idol Huitzilopochtli"; in the answer from

Tequizistlan

In ancient times the Indians came from Chicomoztoc in the land of the Chichimecs and peopled the town of Tequizistlan and the other districts. They had as their lord Izcuin, who wore a cloak of coarse agave fibre, a loin cloth and sandals. Every day they contributed some rabbits and snakes for his sustenance and he had Indian servants who guarded and served in his house. He did not eat fowl. Besides the above they gave him skirts and shoulder capes of coarse agave fibre. He did not use cotton; nor did the natives take him aught beyond what has been stated. They adored the idol Huitzilopochtli and every eighty days they sacrificed thereto the Indians who were condemned to death for crimes they had committed. They lived and were condemned to punishments according to the law of Nature.

Tepechpan

The Indians affirm that in heathen times they formed an independent republic. They paid no tribute to their lords but only acknowledged them as such by giving them daily, hares, rabbits, snakes, quail and domestic fowl. They were Chichimecs until some years later a cacique of somewhat greater culture, named Axoquauhtzin, became their ruler. To him they contributed, every eighty days, four loads of coarse agave-fibre cloths, each load containing twenty cloths and eighty sandals; also four loads of the finer cloths made of agave fibre called "ayates." Later on, fifty years previous to the reign of Montezuma, lord of Mexico, the lordship of Tepechpan was held by Tencuyotzin, to whom the natives of said town began to yield tribute. Every eighty days they brought him fifty cotton cloths four legs (*piernas*) wide and eight arm-lengths long; and also thirty other cotton cloths four arm-lengths long and four legs wide; also forty other cloths for wearing worked with rabbits' wool and twenty loads of cocoa from Soconozco, each load containing twenty-four thousand cocoa beans; also forty skirts and as many shoulder capes (for women); twenty loads of chili peppers and as many of seeds.

Tepechpan, that "they had no idols and worshipped the Sun daily"; in the answer from Acolman, that "they adored Tezcatlipoca"; and in that from Teotihuacan, that "their principal idol was Huitzilopochtli," but that "for greater veneration, this had been placed on the hill of Chapultepec," a statement that may have been made for the purpose of warding off any search for this idol being made at Teotihuacan.

They had no idols and worshipped the sun, offering it daily, snakes, butterflies and some game birds. The man who first found any kind of the above creatures, at whatever hour of the day it might be, cut off its head and, turning towards the sun, offered it so that the sun should protect him that day. They had no other rite or custom and occupied themselves with hunting.

Acolman

In ancient times, when they were heathens, the natives of Acolman, those of Coatlinchan in the district of Texcoco, and those of Atzcapotzalco named Tepanecs, knew no alien lord and only rendered obedience to their native lords until about twenty years, more or less, before the Marques del Valle arrived and conquered New Spain, one Nezahualcoyotzin, lord of Texcoco, allied himself with Montezuma, lord of Mexico, and tyrannized over the whole region.[1] Afterwards the natives of the town began to render tribute to the lord of Texcoco, but only to the extent of furnishing him with fighting men in war time. To their native lords they had formerly paid, as tribute, a load of coarse agave-fibre cloths, twenty in a load and another load of thin agave-fibre cloths; a load of women's shoulder capes of thin agave fibre; a load of petticoats of the same and some fowl (they did not know how many). Every day they contributed a load of dried agave leaves to be used for fuel, and another load of the wood of the wild cherry tree. Their lord had, in his house, Indians who guarded and served him. They adored Tezcatlipoca.

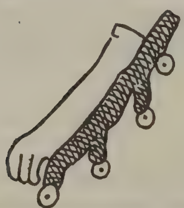


Figure 2
Place-name of Acolman

When they returned from warfare and brought some prisoners they assembled by order of the lord and held a festival, taking those who were to be sacrificed to a great temple which is in the said town. They were decked with rich cloths, carried flowers in their hands and danced until they reached the summit of the pyramid temple where they tamely submitted to being stripped and thrown backwards on a large stone on the edge of which they were stretched, their head and legs hanging and their breast taut. A

[1] Instead of "twenty years, more or less," read "ninety years," the final Conquest of Acolman and Teotihuacan and adjacent country by Nezahualcoyotl and his cousin Montezuma the Elder having taken place in 1429.

cut was made across the body below the ribs with a flint knife and the heart was torn out. This was carried in a painted gourd bowl to the idol and was cast before it. Old men were specially appointed for this office and they took the dead body and placed it in a bath. After it was well washed with hot water they cooked and ate it, dividing it between the chieftains and captains. They lived according to the law of Nature.

The Indians who distinguished themselves in warfare, took prisoners and killed enemies, were authorized to wear on their heads in peace times as a mark of distinction, white feathers stuck on with paste. In the month of March they celebrated a feast which they named Tlacaxipehualiztli which means "the flaying of a person." It was ordered that during twenty days the slaves who were to be sacrificed danced every day, singing sad songs, carrying certain shields and flowers in their hands and wearing a kind of wide shirt sewn together at the sides and named "xicalco."

When, at the end of the twenty days, they were to be sacrificed they were taken to the summit of the pyramid temple where the idol was. After the heart had been torn out and offered to the idol, the corpse was thrown to the base of the pyramid and beaten with rods until the skin became raised.[1] Then they flayed it and an Indian clothed himself with it and ran about the neighboring towns showing himself and begging for alms. He was given maize and *huauhtli* and other things, all of which was given to the owner of the sacrificed slave who, twenty days after the sacrifice, took the flayed skin and buried it publicly in the temple of the idol. Inviting all the lords on the day of the burial, they consumed all the edibles which had been collected as alms. On the day when the slave was sacrificed the lords arrayed themselves and danced all day long and partook of the flesh of the victim. On the day when the skin was buried they beat a drum in the temple of the idol, at the sound of which all Indians who were working in their fields ran and shut themselves up in their houses. For the Indian who had worn the skin ran all over the country and if he found anyone working in the fields he shaved the top of his head and thus made him a slave. If he found no living soul, instead of hair

[1] According to Señor Troncoso y Paso, this method of treating the skin before flaying the body was also used by the Indians of Teutitlan. It was probably the method generally employed in the gruesome rite.

he had to cut agave leaves to bring back to the temple. They observed the custom of burning incense every twenty days in a circular building nearly two yards high. The vassals daily burnt incense in their homes.

The festivals they observed every twenty days had different names. One of them was named Suchimanaloya, which means "the gathering of flowers," [1] it being the custom to gather, on that day, many flowers in the hills and plains and to place them where they burned incense without any further rite or ceremony. Another festival was named Hueytozoztli, its ritual being that, three days previously, they gathered some of the earliest maize shoots and tied them in bunches with bean-blossoms. On the feast day they carried these to the house of the owner of the field in which they had been gathered and laid them on a clean mat. In front of said bunches they placed as an offering, a small basketful of *pinole* which is made of roasted and ground maize, and a basket of tamales and on the top of the basket a cooked frog [2] with its limbs stretched out. It was their intention thereby to appease their idol so that it would give them a good harvest. When the said feast day had passed the owner of the field in which said maize shoots had been gathered, ate the offerings. They had another festival named Toxcatl, the ceremonial of which was to take maize from the fields and roast it and when it popped and burst to string the pop-corn for necklaces and chaplets which they wore on their necks and heads. The old people danced, rejoicing at the good year conceded to them.

Another festival was named Etzalqualiztli and its ritual was that they took maize, beans, *huauhtli*, and all kinds of seeds they cultivated and made tamales of them all mixed together. Small groups consisting of five, six or ten persons went dancing through the streets and into houses and the palaces of the lords where they offered each other the aforesaid tamales as a sign of festivity and rejoicing.

They had five other festivals named Tecuilhuitontli, Hueytecuilhuitl, Miccailhuitl, Hueymiccailhuitl and Ochpaniztli in which

[1] This seems to have been a local name for the festival that is usually named "Tozoztli" — the feast that followed it being designated as "Huei-tozoztli" or "the great Tozoztli."

[2] The frog was the emblem of the goddess of water, and she was worshipped under this form. An "extremely beautiful Temple of the Frog, the goddess of Water" is mentioned by Ixtlilxochitl (Obras Históricas . . . ed. Chavero, Mexico 1891, Tomo I, p. 37) as having been built by the Toltecs in the ninth century of the Christian era by Mitl.

the only ceremony observed was the burning of incense in front of the idol. They had another festival named Tepeilhuitl which means "the feast of the mountains," the ritual of which was that whenever an Indian, on going to fetch fuel, found any piece of wood or branch which was crooked or twisted, he brought it to his house and when this festival arrived, covered it with the dough named *tzoalli*, placed it on a clean rush mat, and when the festival was over, ate the dough. They had another festival named Quecholli, the ritual of which was to take dry canes and make arrows of them, decorating them with feathers. Early in the morning of this day all the common people assembled arrayed for warfare and went hunting. They then danced with the produce of their hunt such as rabbits, rats or snakes, and ate them with tamales made of maize and the sweet juice of the agave.

They had another festival named Panquetzaliztli, in which the boys of the town aged ten years or less, wearing rich mantles, danced in honor of the idol in the temple square. During the other two festivals named Atemoztli and Tititl, the sole ceremonial was the burning of incense before the idol.

Another festival was named Izcalli and its ritual was that after midnight they took their children and holding their heads between the palms of their hands lifted them repeatedly so that they should grow rapidly. At the same time they also feasted and drank.

In another festival, named Quahuitlecua, their ritual was that the chieftain took many folded sheets of paper and joining them together made [something] like a lance. He then went to the top of some hill where they had their idols, followed by all the common people and there they offered the papers and burnt incense and covered the idols with cotton mantles, leaving them there until time destroyed them.

Teotihuacan

In heathen times its people constituted a republic which recognized no authority but that of its natural lords who were [of the race] named Chichimecas, until Netzahualcoyotzin, lord of Texcoco, made war and tyrannized over the whole territory, killing sons of Tetzotzomoctzin, lord of Atzcapotzalco, to whom all rendered allegiance. After the death of Tetzotzomoctzin the said Netzahualcoyotzin made himself powerful by making an alliance with Montezuma, lord of Mexico. They divided between themselves the lands of the towns of Teotihuacan and Acolman. The inhabitants of Teotihuacan, in recognition of their overlordship, paid them as tribute, every eight days, some blankets made of coarse agave fibre, named *ichtilmates*, and some loads of agave leaves, named *metlontli*.

Their principal idol was Huitzilopochtli which for greater veneration was placed on the hill of Chapultepec in the City of Mexico. Aside from this there were other minor idols in the town of San Juan which was the temple and oracle to which the inhabitants of all neighboring towns flocked.

In the said town there was a very high pyramid temple which had [stairs with] three landing places [terraces] by means of which one ascended to the summit.[1] On its summit was a stone idol they named Tonacatecuhlli, made of a very hard, rough stone all of one piece. It was eighteen feet long, six feet wide and six feet thick, and faced the West.[2]

In the level space in front of said temple, there was another small one, eighteen feet high, on which was an idol smaller than the first, named Micttlantecuhtli, which means Lord of the Underworld. This faced the first and was seated on a large stone six feet square. A little farther to the North was another [pyramid] temple slightly smaller than the first, which was called "the Hill of the Moon," on the top of which was another great idol nearly eighteen feet high which they named the Moon. Surrounding this [pyramid] temple were many others, in the largest of which were six other idols called "the Brethren of the Moon," to all of which the priests of Montezuma, the lord of Mexico, with the said Montezuma came to offer sacrifices, every twenty days.[3]

[1] This positive statement that the pyramid of the Sun at Teotihuacan consisted of three stages is confirmed by the representations of both pyramids in the accompanying Map (Plate 1) and in that made by the famous cosmographer Alonso de Santa Cruz (see Plate 2, lower right-hand side).

[2] The stone idol described here is the "image of the Sun" mentioned by Gemelli Carreri who in 1697 was shown a fragment of it that had been thrown from the summit of the pyramid of the Sun and had, on account of its great size, stayed half way down. Ixtlilxochitl, the native historian, who resided at Teotihuacan, states that Tonacatecuhlli signified "God of Sustenance" ("Tonacayotl"—human sustenance or the fruits of the earth, and "Tecuhlli"—lord) and that this was one of the principal gods, in the figure of the sun, the other being his wife, in the figure of the moon. (Obras Históricas de Don Fernando de Alva Ixtlilxochitl, ed. Chavero, Mexico 1891, Tomo I, p. 39.)

[3] This statement that Montezuma and his priests came to Teotihuacan every twenty days is of extreme importance and interest, for it reveals that this ancient Toltec capital continued to be a great religious centre down to the time of the Spanish Conquest.

During the entire year they observed eighteen festivals, or one festival every period of twenty days. Each festival had its different ceremonials as is set forth in paragraph fourteen of the description of Acolman to which I refer.

Every four-year period closed with a feast on the number twenty but in the bissextile year there were five days in excess and they then held a feast in a large square that was situated between the two pyramids. In the centre of this square there was a small platform about twelve feet high on which they punished evil-doers and delinquents.

QUESTION XV

State how they were governed; with whom they carried on warfare; how they fought; the clothes and costume they wore and now wear and whether they used to be more or less healthy than now and the reason that is known for this.[1]

[1] It is an interesting and instructive fact that, in reports from a number of towns, situated in different parts of Mexico, the answers to Questions V and XV unanimously and invariably relate that previous to the Conquest the natives enjoyed better health and longer lives and that the physical deterioration since then was due to the living in towns, the use of more clothing, a greater license and independence, and the indulgence in a meat diet and *pulque*. The following reports from towns pertaining to the diocese of Oaxaca, corroborate these and are particularly explicit and illuminating:

"The oldest inhabitants state that the reason why the natives are more shortlived nowadays than in heathen times is because anciently they did not sleep in towns or settlements; and ate naught but dry tortillas made with great labor and care. Thus they lived strong and healthy and when they married they were at least over thirty years of age and thus led healthy lives. After the Spaniards came they built houses and lived in peace and tranquillity; ate an abundance of different foods; wore clothes and indulged themselves. The boys marry at twelve and fifteen, and all these things, as it is reasonable to suppose, cause them to be more shortlived nowadays." (Town of Chichicapa.)

" . . . In olden times the natives lived a hundred years or more and now they die young and what they say and explain and communicate to each other on the subject is that the reason for this is that anciently the children were put to work at the age of six or seven. As there were so many wars there was no time to cultivate much and so they ate little, slept in the open and were fitted to live in constant labor. After the Spaniards came they wore clothes, slept in houses, ate and drank and indulged themselves much. In those days an Indian married at forty and now at twelve or fifteen. . . ." (Town of Ocelotepec.)

" . . . They used to fight with the natives of other neighboring towns for no cause or reason whatsoever, only for the exercise and they ate the flesh of those they captured alive in battle, and not that of those killed in warfare. . . . They ate tortillas or tamales and some chile and no more. Once a year when they celebrated their harvest, they killed a hen, chicken, dog or rabbit (if able to catch it) or other game and ate it, offering first of all to their idol the first fruits of all they caught or killed — for in all things they were subjected to strict laws. . . . They say that notwithstanding the hard work they used to suffer under, they used to be healthier . . . they say an Indian used to live more than a hundred and twenty years and now it is a great deal if the age of eighty is reached, although the natives now lead such an easy life and are the masters of their properties which formerly they were not, for no one then dared eat anything they raised under pain of fine or death." (Town of Iztepexi.)

" . . . Their ordinary food used to be tortillas and chile and beans and if anyone hunted a deer, rabbit or mouse they ate it although usually they presented it to their native lord who

Tequizistlan

The natives of this place had no government. All they understood was to hunt and to cultivate very little land. They had never been at war or quarrelled with anyone until Nezahualcoyotzin, the lord of Texcoco, conquered the district and allied himself with Montezuma, lord of Mexico. They made vassals of the natives of this town and distributed among their sons the lands they owned. They fought with bows and arrows, and clubs garnished with obsidian points. They had shields made of hard cane. Their war costume was of the skin of rabbits and other animals and feathers of birds, and in time of peace they went naked and only used coarse mantles of agave fibre and loin cloths. The chiefs wore sandals. Nowadays all in general wear cotton mantles, shirts and trousers and the women cotton shirts and shoulder capes. Some use woollen mantles. They sleep high and cover themselves with woollen blankets.

In ancient times their food consisted of snakes, cactus and cooked agave leaves and some herbs of little nourishment with which they lived heathily. Nowadays they are accustomed to eat game birds and domestic fowl, baked bread, also other products of the lagoon, with which they are not as healthy as in olden times because they have more luxury now than they had then.

Tepechpan

According to what the natives say, they governed themselves according to the law of Nature. For many years they lived in peace, without being at war with anyone until, two hundred years before the time of Montezuma, they had some encounters with the lords of Mexico who wanted to subjugate them, whereas they

would give them some of it or some other food or clothing as a compensation, because only the lords had permission to eat turkeys, quail, deer and other game. Nowadays everybody eats tortillas, chile, beans, gourds and deer although they cost excessive prices, also other meats of our cattle or of the game they kill. . . ." (Town of Tepeucila.)

"They use at present the same foods they used to but have many meats, as they eat sheep, ewes and cows, there being no town which does not have its community ranch and private ones, thus having meat in abundance. . . . As the reason why, in ancient times, they lived much longer, all dying old then and young nowadays, they say it must be because they work less now than they used to, having then to render personal service not only to the caciques and lords but also to the 'Tequitlatos' who were those who were in charge. Also because nowadays they marry in boyhood, whereas formerly they did so at the age of thirty or forty. . . ." (Town of Miahuatlan.)

defended themselves so as not to receive their evil customs. They became confederates by means of a marriage. A hundred and twenty years later a lord of Atzcapotzalco near Mexico, named Maxtlaton, with despotism killed Tencoyotzin, lord of Tepechpan, in order to increase his dominion, for which reason they waged war against Atzcapotzalco and joined the Mexicans and made war on those of Soconusco and Tlaxcala and Huejotzinco and the province of Michoacan.

The chieftains wore a loin cloth named *maxtli*, no shirt, and mantles worked with designs, also bracelets and labrets of stones named *chalchihuites*. Ordinary men went naked with a loin cloth only and a mantle of agave fibre. Nowadays they generally wear cotton mantles, shirts and loose trousers; only a few wear loin cloths. The commonest foods they have always used and still use are maize, beans, squashes, *huauhtli* and chili peppers.

After the arrival of the Marques del Valle they ate fowl. The natives state that before he came they had never had any remarkable illness but that about a year before his arrival, a great number of them died of a disease like small-pox which broke out all over their bodies. Since then they have never been free from illness, they do not know why.

Acolman

The lord of Acolman used to govern his Indians and punished those who committed crimes. If any chieftain committed a crime this was investigated by the lord of Texcoco.

The people of Acolman carried on war with those of Tlaxcalla and the mountain range of Metztitlan, and fought them with bows and arrows, wooden sabres with obsidian points, and wore cotton mantles. In time of peace the chieftains always wore fine loin clothes, mantles of agave fibre, and sandals, excepting at festivals when they wore mantles worked with designs. When they went out, in order to protect themselves from the sun, each carried a feather fan. All vassals wore only a mantle of coarse agave fibre and a loin cloth. Nowadays all generally wear cotton shirts and mantles and trousers; they cover themselves at night with blankets, whereas in ancient times they only covered themselves with the mantle they wore in day time. The chieftains used to eat game birds and some domestic fowl. The commoners only ate the cooked leaves of the cactus or agave and other wild herbs. Nowadays all generally eat maize bread and chicken and beef or mutton.

Previous to the Conquest, in olden times, they were very healthy but nowadays they suffer from disease and do not live as long. The natives believe that it is on account of the little work and much feasting that they now have.

Teotihuacan

They governed by means of some laws they had, in accordance with which they punished malefactors. One of these laws decreed that those who committed adultery and were found *in delicto fragranti*, were handed over to the relatives of the offended party and were beaten to death publicly within two days. If by chance the offended one forgave the crime the pair were not punished beyond the fact that the wife was separated from her husband. If the latter returned to her he incurred penalty of death for he was regarded as having consented to the adultery committed. This law only applied to the wife who had been received by the husband after negotiations with her relatives followed by the celebration of a wedding, during which the bride and groom were anointed with a yellow pitch or wax named *jahuali*. The woman who had received a man without this ceremony was a concubine and not a wife and even if she committed adultery she was not punished.

The person who stole ears of corn, squashes or beans, even though he were a child, was condemned to pay for each stolen ear or squash, a woollen blanket named *quachtli*. If he had no means of paying he incurred the penalty of death and his head was publicly pelted with stones as a warning to others. Adults who stole clothing, feathers, stones or other articles of value incurred the death penalty if the stolen goods were not restituted. In the latter case the thief became a life-long slave. When an Indian man and woman, married according to the customary ceremonies, happened not to treat each other well and often quarrelled, the chieftain or elder of the quarter in which they lived, summoned them and inquired what was the reason of their disagreement. If, being a regular wife, she complained that her husband did not provide her with necessaries, or that, instead of supporting himself by working in his corn-fields or farm he amused himself, this constituted a cause for separation, as was also the case when the wife was lazy and did not serve her husband. An equal division of property was made when a separation took place.

The slave who escaped from his prison and made a public declaration that he had done so before the elder of his quarter, was acquitted of his imprisonment and set free by said elder. If war captives, while being led to the temple to be sacrificed to the idol, were by chance able to escape and reach the summit of the pyramid where the idol was, and get behind this, he was acquitted of said death and sacrifice.

The inhabitants of Teotihuacan used to carry on warfare with the people of Huejotzinco and Atlixco and used to fight with bows, arrows and wooden sabres edged with sharp obsidian points (*macana*). The usual costume of the chieftains in time of peace consisted of a mantle of fine agave fibre, a loin cloth and sandals. In war time the chieftains and others who had distinguished themselves in warfare wore a cotton armor and various devices; some disguised themselves as herons, or ducks, or eagles. Others disguised themselves by wearing the skins of pumas, jaguars, wolves (coyotes), deer or other animals. The common Indians only carried bows and arrows and wore no device whatsoever. They went naked excepting for a loin cloth and coarse mantle of agave fibre. Nowadays they all wear cloaks, cotton shirts and trousers; they sleep on beds and cover themselves with woolen blankets. They eat good food, boiled maize, domestic and wild fowl, beef and mutton.

In ancient times most of them sustained life on the boiled leaves of the cactus and agave, or roots, or mice, snakes and other reptiles, and were healthier because of this and because they were more accustomed to exercise and hard work than nowadays. The natives realize that the luxury they now live in and the little work they do is the cause of illness, because they now fall ill whenever they make any exertion, especially on account of the *pulque* which they are accustomed to drink from childhood and which does them much harm.

QUESTION XVI

It is to be stated, about all towns of Spaniards or Indians, whether it is situated in a mountain, valley or open plain, and the name of the mountain or valley. The district is to be recorded with the meaning of everything in the native tongue.

Tequizistlan

This town is situated in a plain, among canals and close to the lagoon. Towards the North it is open on all sides but there is a small mountain there which is named Tlahuilquitl because the natives say that in ancient times they saw fire come out of said mountain and that it illuminated a great part of the country; therefore they call it the "mountain of light." [1] To the Northwest there is another large mountain within its boundaries. It is named Yelocotl because it has plentiful game, so the Viceroys of this New Spain have used it as a hunting ground.

Tepechpan

The town is situated in a plain at the base of a rough hill and is open to all sides. Near it, at a distance of a quarter of a league, in the confines of Texcoco, there is a medium-sized, round hill which is named Tlahuilquitl, thus named because the natives say that in said hill there used to be fire which gave light at night; therefore they named it "the mountain of light."

Acolman

Acolman is situated at the foot of a hill, in a plain open to all sides. At a distance of about half a league there is a mountain named Tlahuilquitl and another big mountain named Yelocotl. The meaning of these names is given in the descriptions of Tequizistlan and Tepechpan.

Teotihuacan

This town is situated in a vast plain wherein there are many springs, as has been declared above.

QUESTION XVII

State whether the town is situated in a healthful or unhealthful place and if unhealthful the cause for this, also the kinds of illnesses that are prevalent and the remedies employed for curing them.

[1] It is interesting and important to learn that, within the memory of man, a small volcano in this vicinity was still active. Compare with the evidence presented in note 1, p. 53, tending to prove that the name "Tenan" was given to the large volcano in the same region while it was periodically active. The name "Yelocotl" may be derived from "Yeloa" = a crowded place, or "Yeltia" = to flee or cause to flee.

Tequizistlan

The situation of this town is unhealthful on account of being very damp. Its inhabitants suffer from fever and cure themselves with nettles and a kind of lily, which afford them some relief.

Tepechpan

The situation is healthful. The usual illness is fever which proceeds from their working in their seed lands. They cure themselves with cooling things. Those that are to die only live eight days.

Acolman

It is a place of medium healthfulness and has bad night dews. The prevalent illness among the Indians is headache which they cure with cooling herbs.

Teotihuacan

It is a healthful region although the natives sometimes suffer from headache and fever, which maladies they cure with herbs and roots of cooling qualities.

QUESTION XVIII [1]

How far or near is any remarkable mountain or mountain range; in what direction does it lie and how is it called?

QUESTION XIX

State what principal river or rivers pass close to the town; at what distance they do so; how abundant they are and whether there is anything remarkable about their sources, their water, its water-supply and the land it irrigates, also whether it is employed or could be employed for irrigation on an important scale.

QUESTION XX

Cite the remarkable lakes, lagoons and fountains and any notable things there may be in the district of the towns.

[1] As the answers to Questions XVIII to XXI, and from XXIII to XXVII, are either omitted or scant, these questions are grouped together.

In the case of Question XXXII and others to which no answers are given, the questions are printed as being interesting in themselves and completing the questionnaire.

QUESTION XXI

Mention the volcanoes, caves and all other remarkable and admirable works of nature there may be in the district, which are worthy of being known.

Tequizistlan

At the East of this town the river named San Juan passes in a deep canal at a distance of two arquebuss shots and it irrigates nearly half a league.

Tepechpan

To the East of the town at a distance of half a long league, at the confines of Texcoco, is a range of mountains, the names of which are not given as they are not very noteworthy. There is no river or fountain, only the river of San Juan passes through the town, dividing into two canals which irrigate the land of said town for a distance of half a league.

Acolman

The river named San Juan passes through the town of Acolman, dividing into four canals, each conveying the measure of two oxen of water and irrigating nearly a league of land.

Teotihuacan

Towards the North lies a big mountain which the natives name Tenan and it has given birth to many other mountains. On the eastern slope of the aforesaid mountain, about half way up, is a chasm in which one hears a great noise which appears to proceed from the interior, at a distance of twenty yards. This seems to be the noise of the water which descends from the said mountain. The natives are convinced that it is water, because in the whole plain that extends between the town of San Juan and the confines of Texcoco there is no river nor spring other than the one at the head of the town of San Juan which the natives associate with the water which makes a noise in the mountain.

In said plain, for a circumference of a league, between the head of the town of San Juan and Otumba, there are many large and small caves, some as extensive underground as an arquebus shot. From these they extract the saltpeter with which gun powder is made in His Majesty's Munition House in the City of Mexico. Thirty Indians are usually employed every week in extracting said saltpeter and the train of mules which conveys it to the City of Mexico is famous.

QUESTION XXII

Describe the native trees that commonly grow wild in said district, and the profit gained from their fruits and wood. State what they are or might be good for.

QUESTION XXIII

Mention whether the cultivated trees and fruit trees in the district brought there from Spain or elsewhere do well or not.

QUESTION XXIV

Mention the grain and seeds and other plants and vegetables which have served or serve as food for the natives.

QUESTION XXV

State what plants have been introduced there from Spain and whether wheat, barley, wine and the olive flourish; in what quantity they are harvested and whether there are silk-worms or cochineal in the district and in what quantities.

QUESTION XXVI

Mention the herbs or aromatic plants with which the Indians cure themselves and their medicinal or poisonous qualities.

QUESTION XXVII

Describe the native animals, birds of prey and domestic fowl and those introduced from Spain and state how they breed and multiply.

Tequizistlan

They have trees of the native cherry and a quantity of agave plants which yield sweet juice and fibre. When cooked the leaves furnish food and when dried supply fuel. They have no other fruit trees, for the earth contains saltpeter and they could not grow. The seeds they sow are maize, *chia*, *huauhtli*, and beans, also some wheat, about fifty fanegas [bushels] more or less. They breed dogs from Spain and some native ones which multiply. Of the wild native animals there are coyotes, and some hares and rabbits.

Tepechpan

Within the confines of this town there are some quince and peach trees and some native cherry trees. In one of the dependencies named Maquizco they grow a quantity of pear, peach and quince trees which give fruit at Christmas. Throughout the whole district there grow quantities of agaves which yield sweet juice and fuel. The natives cultivate and gather for their food maize, beans, squashes, peppers, *chia*, and *huauhtli*. Of Spanish vegetables they have lettuce, radishes, onions and parsley. They have wheat which, although the quantity is small, serves as provision for the natives. They have raised quantities of dogs of those brought from Spain and a few of the native ones. Of wild animals there are coyotes.

Acolman

They have a quantity of the native cherry tree which produce much good fruit. They have walnut, pear, and quince trees and vines in the orchard of the monastery of this town. Of agave and cactus plants, which are the principal food of the natives, there is an abundance. They cultivate maize, beans, *chia*, and *huauhtli*, on which they live. They have no other vegetables out of carelessness, for they would grow well in this district. They cultivate wheat with and without irrigation, and it does very well, but they only sow a small quantity.

Teotihuacan

They have an abundance of the native cherries, of the edible cacti and agaves which sustain them, and which they sell in the neighboring towns. In said town and its confines they harvest much maize, beans, *huauhtli*, and *chia* for their maintenance. They also raise some Spanish vegetables. The natives sow but little wheat although what is raised is very good.

QUESTION XXX

State whether there are salt works in or near said town and from where they get their supplies of salt and of all other things they need for sustenance and clothing.

Tequizistlan

In ancient times they used to make salt in this town with which they provided the City of Mexico. For the past thirty-eight years they have given up doing so because the number of inhabitants have decreased and because the water of the lagoon has risen and covered the salt beds from which they extracted the salt.

Tepechpan

They lack salt and procure what they need from the City of Mexico or the town of San Cristobal Ecatepec or from Exquipayaque, a dependency of Texcoco. For their clothing they procure cotton from the estate of the Marques del Valle.

Acolman

The salt they use is brought from the towns of Tequizistlan and Acatepec and Mexico; the cotton which they use for clothing themselves is brought from the land of the Marques del Valle and from the mountain of Meztitlan.

Teotihuacan

There are no salt beds in said town or its dependencies, so all that is consumed there is brought from the City of Mexico, from the town of San Cristobal or from the mountain range of Meztitlan and the hot lands. The cotton they use for clothing is brought from the region of Panuco.

QUESTION XXXI

Describe the form and construction of their houses and the materials for building them that are found in the towns or the other places from which they are brought.

Tequizistlan

The houses and constructions in which they live are generally built with stone foundations and adobe walls covered with flat roofs. The stone needed for building is to be had in the neighborhood. The timber required is brought from the woodland of Texcoco, distant four leagues.

Tepechpan

All of the houses in this town and its dependencies are generally built with stone foundations, adobe walls and flat roofs.

Acolman

All of their houses and structures have stone foundations, adobe walls and flat roofs. They have an abundance of stone.

Teotihuacan

All the inhabitants of this town and its dependencies live in houses built of stone and adobe, with flat roofs. The houses of the principal personages are curiously and elaborately constructed.[1]

QUESTION XXXII

Describe the fortresses in said towns and the strongholds there are in their vicinity and within their confines.

QUESTION XXXIII

Describe the trade and traffic and dealings with which the Spanish and native inhabitants of the town support themselves and state with what produce and how they pay their tributes.

Tequizistlan

The Indians live by farming. They have the custom of buying cotton brought from the Marques del Valle and of this they spin and weave skirts and mantles (*mantas*) with designs, that they sell. The natives of Acaltecoya, subordinate to Tequizistlan, deal in fish and game birds and pay their tribute with these.

[1] In a document dated 1563 mention is made of the great palaces then occupied by Alonso Bazan, a descendant of the Kings of Texcoco, who was the native lord and *encomendero* of Teotihuacan.

Tepechpan

The inhabitants of this town live by cultivating their lands and raising hens and have no other trade or dealings. They pay their tribute to their *Encomendero* in agaves, money and maize as is generally done by the other towns in New Spain.

Acolman

The inhabitants live by farming and raising hens and have no other trade or dealings. With their profits and the sweet juice of the agave, they pay their tribute in money and in maize.

Teotihuacan

The natives incline to farming and its produce is their principal means of support. They raise Spanish and native fowl for nourishment and have no other trade.

QUESTION XXXIV

State the diocese of the archbishopric or bishopric or abbey to which the town belongs; the district in which it is situated and its distance in leagues. State in what direction from it lies the cathedral town and the capital of the district and whether the leagues are long or short; the roads straight or winding and the country flat or rough.

QUESTION XXXV

Mention the cathedral or parish church or churches in each town with the number of beneficiaries and prebends in each; if the town contains any chapel or noteworthy endowment, state whose it is and who was its founder.

QUESTION XXXVI

Mention the monasteries of friars and convents of nuns of each order there may be in each town; when and by whom they were founded and the number of friars and nuns therein. Mention also anything noteworthy there may be in the towns.

QUESTION XXXVII

Mention also the hospitals, colleges and pious institutions there may be in said towns and by whom and when they were instituted.

Tequizistlan

This town belongs to the diocese and archbishopric of the City of Mexico which lies to its Southwest at a distance of five leagues of level country. The boundary of the district of Tequizistlan lies to the North of the City of Mexico at a distance of a quarter of a league.

Tepechpan

Tepechpan pertains to the diocese and archbishopric of Mexico and lies in the district of the town of Tequizistlan, a quarter of a league to its North, and five leagues from the City of Mexico, wherein the cathedral stands.

Acolman

The town belongs to the archbishopric of the City of Mexico where the cathedral of the diocese stands, at a distance of five long leagues of level country. In Acolman there is a monastery of friars of the order of Saint Augustine, in which there is a school in which grammar is taught. Twenty-four monks reside therein and five priests for the administration of religious doctrine to the natives. They have a very grand church with a vaulted ceiling and a very sumptuous portal of carved stone; also a good orchard within the monastery walls, in which they gather quantities of Spanish walnuts and cherries, of native cherries and plums. This monastery was founded in 1539, the provincial of the order of Saint Augustine being the reverend father Friar George Davila.

Teotihucan

The town of San Juan and its dependencies pertain to the diocese and bishopric of the City of Mexico and is two leagues distant from Tequizistlan, the headquarters of the Corregidor. In San Juan there is a monastery of Franciscan friars who administer the doctrine to the natives. They have a good church and fair house in which three priests and a lay brother generally reside. The monastery was founded in 1566, the provincial of the Franciscan order being Friar Miguel Navarro and the guardian of said town Friar Francisco Perez.

Paragraph L

And after the said description has been written down, it is to be signed by the persons who helped to make it. It is to be sent without delay with this instruction, to the person who may have forwarded it.

Tequizistlan

The description of this town was written therein on the twenty-second of February, 1580, and was signed by the Corregidor Francisco de Castañeda and those who knew how to write, namely Juan de Vera, Antonio de San Francisco, ... [an illegible name followed by the word *fiscal*, that is prior or censurer].

Benito Martinez, *clerk*.

Tepechpan

Description written in the town of Tepechpan on the twenty-third of February, 1580, and signed by the Corregidor Francisco de Castañeda, and those who could sign: Juan de Vera; Don Antonio de Herrera; Rodrigo de Sandoval.

Benito Martinez, *clerk*.

Acolman

The description of the town of Acolman, under the *encomienda* of Francisco de Solis, citizen of Mexico City, was written in said town on the twenty-sixth of February, 1580, those present while it was being drawn up being: the Corregidor Francisco de Castañeda, Benito Martinez, Alonso de Solis, Francisco de Miranda, and Juan de Vera, Spaniards; Don Diego Vazquez, Governor, Don Guillermo de San Francisco, Alcalde, Lucas de Molina, Don Cristobal de Santiago, Pablo Zihuatecpanecatl, Regidors; Don Juan Bautista, Diego Atecpanecatl, and Antonio de Santiago, chieftains and natives of said town.[1]

[1] The above entry appears as a superscription to the report from Acolman and the signatures follow separately at the end.

Signed by the Corregidor Francisco de Castañeda and those present who could write, who were Juan de Vera; Guillermo de San Francisco, Alcalde; Diego Vazquez, Governor.

BENITO MARTINEZ, *clerk.*

TEOTIHUACAN

The description of the town of San Juan Teotihuacan, under the charge or *encomienda* of Don Antonio Baçan, Chief Alguazil of the Holy Office of the Inquisition,[1] was written in said town on the first of March, 1580, there being present Don Cristobal Pimentel and Luis de San Miguel, Alcaldes; Antonio de San Francisco, Mateo Juarez, and Antonio de los Angeles, Regidores; Andres Dalbiz, Don Lorenço and Francisco Quaunochtli, chief Indians of said town; Alonso de Servantes and Juan de Vera, Spaniards. It was translated by Francisco de Miranda; interpreted and signed by the Corregidor and those who knew how to write: Francisco de Castañeda, Andres Dalbiz, Damian Bravo, Gabriel de la Cruz, Francisco de Miranda.

BENITO MARTINEZ, *clerk.*

[1] It is deeply significant and illuminating to find that absolute authority, civil and ecclesiastical, was wielded in Teotihuacan, the ancient religious centre, by Don Antonio Baçan, who, like his brother Don Francisco before him, was an Inquisitor of high rank, being Chief Constable of the Holy Office. There can be no doubt that much of the destruction and covering up of the ancient monuments in Teotihuacan must be attributed to the Inquisition, whose officers systematically and ruthlessly carried out the policy of exterminating idolatry, initiated by Cortés and Bishop Zummaraga, a task in which they were enthusiastically aided by the native Catholic neophytes.

Map of Tequizistlan, Tepechpan, Acolman, and San Juan Teotihuacan

A part of the map by Alonso de Santa Cruz (*circa* 1570)

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LESLIE C. DUNN

BASED UPON DATA COLLECTED BY

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NOTE

At the time when Dr. Tozzer gathered the data which are analyzed in this paper practically no measurements had been undertaken on living Hawaiians. Later Dr. Louis Sullivan made most extensive anthropometrical investigations in Hawaii. His lamented death came before his data could be worked up. It has thus seemed worth while to publish the results of the investigation of the present data although they are far less adequate than those collected by Sullivan.

Dr. Hooton, who suggested this investigation, has given amply of his time and attention throughout its analysis, and has seen it through the press owing to the absence of Dr. Dunn in Europe.

The publication is made possible through the kindness of George P. Castle, Esq., of Honolulu, and of Dr. Tozzer.

Charles C. Willoughby, *Director*

Cambridge, Massachusetts,
December 15, 1927

CONTENTS

PART I

An Anthropometric Description of the Native Hawaiians

PART II

Descriptions of Other Races in Hawaii and of Descendants from Crosses of Hawaiians with Other Races

AN ANTHROPOMETRIC STUDY OF HAWAIIANS OF PURE AND MIXED BLOOD

INTRODUCTION

It is the purpose of this report to present and discuss a large body of detailed evidence bearing on the physical consequences of racial hybridization in the Hawaiian Islands. The study was undertaken and the data were collected and analyzed in the hope that the results would contribute towards a solution of the important problem of race mixture. We have regarded this problem chiefly as a biological one, the solution of which depends on the acquisition of knowledge concerning the inheritance and interrelationship of the specific traits which differentiate races. The most needed contributions at present appear to be detailed descriptions of racial traits and of their behavior in inheritance.

This is particularly true of the great problem presented by the population of the Hawaiian Islands. Here, as is evident from the data presented by several observers, e.g. (1, 2, 3) [1], a great natural experiment in racial hybridization is taking place, in which the blood of the native Hawaiian people is being mingled with that of most of the chief racial groups of the world. This amalgamation of diverse races is, as our own observations and those of others show, of comparatively recent origin. The racial elements contributing to the hybrid population are still present in Hawaii together with the progeny of various crosses between them. A tempting opportunity is therefore offered for anthropologists and geneticists to study the inheritance of racial traits.

PLAN OF THE STUDY

It was this opportunity which in 1916 prompted Professor A. M. Tozzer and Professor E. A. Hooton of Harvard University to make plans for studying the races and hybrids of Hawaii. The writer, as a student of genetics, was called upon to collaborate in

[1] The titles of papers which are referred to by number in the text will be found in the bibliography at the end.

the plans, and to undertake the analysis of the data relating to the descriptions of the pure races and of their hybrids. Our plans called for (1) the accumulation of anthropometric data for as many subjects of known race or mixture as could be measured; (2) data on the fertility, longevity, mental capacity, etc. of subjects of pure and mixed races; (3) analysis of these data with the objects of discovering the mode of inheritance of specific traits; the effect of crossing on physical traits, growth, fertility, vigor, etc. and the differences between various racial crosses in these respects. We also hoped to obtain from these data some light on the vexed question of the racial origins and affinities of the population of Hawaii and of other Polynesian peoples as well.

It is not surprising that so ambitious a plan remains unfulfilled; for, with the time and resources at our disposal, we were able to accomplish only a part of what we set out to do. It soon became evident, for example, that the data on hybrid peoples had value directly in proportion to the completeness of our knowledge of the parent races. There proved to be almost no data of value on the physical traits of living native Hawaiians, and it became our first task to make good so far as we were able this deficiency in our knowledge. We also realized that the behavior of racial traits in inheritance, or even the descriptions of racial hybrids could only be established from observations on a relatively large number of subjects from each cross. We therefore limited our efforts to obtaining anthropometric descriptions of living native Hawaiians, and of the descendants of crosses between Hawaiians on the one hand, and members of the Chinese and white races on the other, since these crosses offered the largest amount of material and the clearest differences in parental traits. It is principally this evidence which will be presented in the reports which follow. A general interpretation of the evidence and its relation to other racial crosses has not been attempted, since our own and other comparative data are not as yet complete enough to justify generalizations.

COLLECTION OF THE MATERIAL

The field work for this study was undertaken by Dr. Tozzer, who spent the summers of 1916 and 1920 in and about Honolulu. Prior to beginning the actual work of observation, a standard schedule of measurements to be taken was drawn up by Dr. Hooton, and a technique of measurement decided on and practised which should conform throughout to the recommendations of the current international agreement. (4) The provisions of this agreement, therefore, serve as a description of the methods employed in this study.

The following measurements were taken:

Body
1. Weight.*
2. Stature.
3. Height of Acromion.
4. Height of Dactylion
5. Chest circumference.
6. Sitting height.

Head
7. Length.
8. Breadth.
9. Minimum frontal diameter.*

Face
10. Bizygomatic diameter.*
11. Bigonial diameter.*
12. Nasion-menton height.
13. Nasion-prosthion height.
14. Nasal height.
15. Nasal breadth.

The following observations were made:

1. Skin color (on an unexposed part).
2. Head hair: color, form.
3. Eye color.
4. Eyelids: obliquity of opening, epicanthus.
5. Brow ridges: degree of development.*
6. Forehead: height, breadth, slope.*
7. Nose: height and breadth of root, height and profile of bridge, inclination of septum.
8. Prognathism.
9. Thickness of lips.
10. Dynamometric pressure.

* Measurements taken on only a portion of the series.

Measurements of the circumference of the chest and of the minimum frontal and bigonial diameters of the head were made only on those subjects measured in 1916. Most of the measurements were made on fully clothed subjects, and in some cases shoes were worn. A deduction of from 2 to 4 cm. was made from the height, acromic height, and dactylic height measurements of subjects wearing shoes, depending on the height of the heels worn.

Skin color was recorded for relatively few of the subjects because of the unsatisfactory color scales available and because of the difficulty of finding unexposed areas of skin on which to judge the normal skin color of the subject. Even on those subjects for which observations are recorded, the color determination is of doubtful accuracy because of the possible tanning of the skin. In 1916 skin colors were recorded in terms of Broca's color scale; in 1920 the better scale of von Luschan (Hautfarben-Tafel made by Puhl and Wagner, Rixdorf) was used. Comparison was in all cases made with the volar surface of the forearm in the least exposed part.

Hair colors were distinguished by name only and the following terms used in recording: black, very dark brown, dark brown, brown, light brown, reddish brown and yellow.

Hair form was recorded as straight, wavy (slight or medium), curly, frizzy, kinky and wiry.

The eye colors recognized were black, very dark brown, dark brown, brown, light brown, hazel, blue, and light blue.

Strength was measured by means of Collin's Dynamometer and the squeeze pressure recorded in kilograms.

In addition to the information noted on the face of the schedule, each subject was questioned concerning his parentage, and the race of his father, mother and other known ancestors was recorded on his schedule, together with any additional or confirmatory evidence concerning his pedigree. Such additional evidence was obtained from school or other public records, relatives, friends, etc. An effort was made also to get information concerning the relative fecundity and viability of the various races and hybrids; and to this end, the number of children, in the case of parents, or of brothers and sisters in the case of unmarried subjects; was sought for and recorded. The absolute amount of information obtained in this way was too meager to be of use and is not reported here.

The choice of the subjects to be observed was governed in the 1916 observations by a desire to obtain data on pure Hawaiians and on crossbred subjects in general. In 1920 a particular effort was made to increase the series of pure Hawaiian observations, and to obtain data on hybrids involving Hawaiian as one element in the cross. The series obtained cannot be regarded as a random sample of the Hawaiian population, as far as the frequency of pure races or of hybrids other than Hawaiian are concerned. It does give a fair sample of the frequency and the stage of mixture between Hawaiian and other races, since all available persons who had any Hawaiian blood were measured.

In respect to social, occupational, and local groups, it is improbable that a purely random sample of the population was secured. The chief departure of our sample from a random one is its inclusion of a relatively large number of subjects from each of a few occupational groups. The individuals measured may roughly be classified as follows: fishermen, police, stevedores, teachers, members of Y. M. C. A., Y. W. C. A. and kindred organizations, school students, workers in pineapple factories, and attendants at an Hawaiian church. The fishermen, police, stevedores, and possibly the teachers, are from selected groups, probably above the average in general size. The school and church attendants probably constitute a random sample, while the factory workers may deviate somewhat, owing to occupational selection. Size characters and variability in general may thus be somewhat higher than normal in a sample including a greater proportion of the larger-sized individuals of the population.

Most of the Hawaiians and part Hawaiians measured were natives of the island of Oahu, on which Honolulu is situated, although in the groups of stevedores and students at the summer school are included a number of natives from other islands in the Hawaiian group; Maui, Molokai, Hawaii, and Kauai. A key to the occupational groups and nativity of the subjects is given in Appendix Table I.

TREATMENT OF THE MATERIAL

Classification of the Subjects

The completed schedules were turned over to the writer for analysis and were immediately classified and grouped for study. All subjects reporting themselves as of one pure race were provisionally grouped together; and, if no evidence from other records or from physical traits appeared to contradict the statement of pedigree, they were regarded as members of that racial group. Considerable care was exercised by the original observer to exclude doubtful persons from pure race groups, and additional precautions have been taken by the writer to exclude any subject with characters obviously abnormal for his supposed group. Such exclusion must be used with care however and is usually not applicable to quantitative characters which are so variable in the purest races. Several eliminations from the pure Hawaiian group were made on the basis of eye color, hair form, and other evidences of mixture, chiefly with a white race or negro.

The cross-bred subjects had to be classified almost wholly on the basis of their own statements, although in many cases these statements could be verified. No check on these statements was available in the physical appearance of the subjects, however, since the inheritance of most the racial traits involved was unknown. Hybrids were classified according to the race of their parents and the number of generations intervening since the original cross. Using as an example the hybrids between Hawaiians and Chinese, the following classes were recognized:

1. F_1 Hawaiian $\times$ Chinese — The direct result of a cross between Hawaiian female and Chinese male, the subject's pedigree reading: mother Hawaiian, father Chinese.

2. F_2 Hawaiian $\times$ Chinese.— The result of a cross between two F_1 hybrids; the subject's pedigree reading mother one-half Hawaiian, one-half Chinese; father one-half Hawaiian, one-half Chinese. The classification of this generation may contain a few errors; since, unless we know the race of all four grandparents, there is a possibility that the parents are themselves second generation hybrids. Because of the comparatively recent introduction of Chinese in large numbers, this is not highly probable. There is also the possibility that "one-half," as a description of a racial element in a parent, is merely a guess, and indicates only admixture of the race named. The number of such hybrids is not large and few wide conclusions are drawn from this generation.

3. BC F_1 $\times$ Hawaiian. — The result of a backcross of an F_1 hybrid to a pure Hawaiian, the subject's pedigree reading: father one-half Hawaiian, one-half Chinese; mother pure Hawaiian.

4. BC F_1 $\times$ Chinese.—The result of a backcross of an F_1 hybrid to a pure Chinese, the subject's pedigree reading: mother one-half Hawaiian one-half Chinese; father pure Chinese.

5. Other mixtures. — In this category are placed those hybrids between two races which have been produced by crosses other

than those outlined above, but in too small numbers to be classified separately.

After such classification, the pure race and hybrid groups were subdivided on the basis of sex, and again on the basis of age. Males of 20 years and older and females of 18 years and over were classified as adult. Means and other constants for quantitative characters have been calculated from these adult series of each sex. In summarizing descriptive, non-mensurable characters the immature subjects have also been included.

Statistical Analysis

The original data have been tabled separately by race, sex and age, and are to be found in the appendix, Tables I to V. The principal ratios or indices calculated for each individual have been incorporated in these tables. From these raw data, the frequency distributions, which are presented by separate measurements in the text tables, have been formed. With the numbers available it has been necessary to use rather coarse groupings in seriating the data for statistical treatment. In general, that grouping has been used which by actual test gave the smoothest graduation, except that for any one measurement, the classification was determined for the males (or the large group), and applied arbitrarily to the females (or the small comparable group).

From the grouped frequencies of the larger distributions have been calculated the mean, the standard deviation, the coefficient of variation, and the probable errors of each of these constants, by the usual formulae as given in treatises on statistical methods (5, 6, 7). In the case of distributions containing few (less than 20) individuals, the constants have been calculated from the ungrouped material.

The variation constants for indices and proportions have been calculated by Pearson's formulae. (8)

$$M_1 = \frac{M_1}{M_2}\left(1 - V_2^2 - r_{1,2}V_1V_2\right) \text{ is for the mean}$$

and

$$\sigma = \frac{M_1}{M_2}\sqrt{V_1^2 - V_2^2 - 2r_{1,2}V_1V_2} \text{ for the standard deviation;}$$

where M_1 is the mean of the first variable such as head breadth, M_2 the mean of the second such as head length, V_1 and V_2 the coefficients of variation (divided by 100) of the first and second variables respectively, and $r_{1,2}$ the coefficient of correlation between the variables. Although the means of indices as calculated by the use of this formula have not differed significantly, in the present study, from the means as usually calculated directly from the frequency distributions of indices, the method here used involves less labor and is probably more accurate than deducing variation constants of indices from the array of individual indices without regard to the correlation between the component variables.

In order to obtain comparative data from cranial material, we have in several cases reduced cranial to cephalic indices by means of the correction factor proposed by Craig (9). Other methods are noted as used.

The separate seriation of measurements by sex and age has resulted in many small and irregular distributions, and we have not tried to combine them by reducing both sexes to a common scale or by correcting the observations on immature subjects to an adult basis. Larger distributions and smoother graduations might have been obtained by this method, yet I believe that there is a basic objection to such a practice. If corrections for age or sex are to be applied, they must be calculated as the differences between the means of two distributions. One must be taken as the standard, and a certain proportion of this standard added to each individual of the distribution to be corrected. This results in no addition whatever to the original data, but only in multiplying the distribution by a portion of itself, along with the errors which attended the original measurements. The resulting amplified distribution appears larger than the standard; its probable error is lowered by the larger number of individuals in it, although the number of original observations remains unaltered. These changes are probably wholly fictitious and likely to be deceptive and it seems a much sounder procedure to face the paucity of numbers and practise the rigid conservatism in drawing conclusions which this condition dictates.

Racial Frequency in Hawaii

A racial classification of all of the subjects observed is given in the table on page 177, and the detailed data on all subjects measured will be found in the appendix tables.

About a third of the 508 subjects measured were pure Hawaiians, while all except a few of the remainder were descendants of crosses between native Hawaiians and other races. The few individuals not included in these classes were scattered among various pure races of the table (A), and mixtures either unknown or not involving Hawaiian (E). The hybrid groups involving Hawaiian as one element have been broken up into (B); those in which only one other race beside Hawaiian was involved, producing a dihybrid combination; (C) those involving two other races besides Hawaiian (trihybrids); and (D) those in which more than two other races participated. The dihybrid groups were by far the most numerous, comprising 247 of the whole 295 crossbred subjects. The trihybrid mixtures were few, only forty-five in number, while numbers of individuals with four races represented in the ancestry were practically negligible. On the whole the more races involved in the ancestry of an individual, the fewer representatives are found, and, incidentally, the less reliable the pedigree as given.

A preliminary discussion of the frequency and approximate dates of origin of the principal racial crosses in Hawaii has already been published. (10) A fuller treatment of this matter, leading to a general picture of racial hybridism in Hawaii, will be given in the parts of this study devoted to the data on the hybrid subjects. At present our chief concern is with the principal and perhaps most interesting single race involved; i.e., the native Hawaiians.

PART I

AN ANTHROPOMETRIC DESCRIPTION OF THE NATIVE HAWAIIANS

Preliminary Statements

Our description of the physical anthropology of the native Hawaiians rests on observations of 158 subjects, concerning whose pedigree there seemed to be no reasonable doubt. Several presumptive Hawaiians were excluded from this classification because of conflicting pedigree records, or by the possession of certain features falling far outside the normal range of variability of the bulk of the Hawaiians observed. Of these 158 subjects, 85 were males and 73 were females. Adults were separated from immature subjects for analysis of all characteristics affected by age, and the constants for pure Hawaiians were calculated from the records of 74 males of age 20 and over, and of 34 females of age 18 and over. The numbers of immature subjects were too small to be treated in separate age groups, nor could they furnish information concerning the changes of the various bodily measurements during growth. Observations taken on these immature subjects have been used in establishing racial norms for such characteristics as hair color and form, skin color, eye color, etc.

The groups on which we must depend for our most reliable information concerning the mensurable physical characteristics of the Hawaiians are these two small groups of 74 males and 34 females. Permanent racial standards cannot, of course, be established on such small samples as these. Nevertheless, since there are no other data on living pure Hawaiians, the constants here given may be used as temporary standards of comparison, until they are supplemented by more extensive evidence.

The Evidence and its Analysis

The raw data for the study of the anthropometry of the Hawaiians are given in Appendix Table I, together with the chief indices and derived measurements calculated for each individual. The grouped distributions and constants for each dimension are given separately in the text tables accompanying the discussion, and all the constants have been summarized in Table 22. These data include for each subject the weight, height, shoulder height, dactylic height, sitting height, head length, head breadth, face width (bizygomatic diameter), face height (nasion-menton), height of upper face (nasion-prosthion), nasal height, and nasal breadth. The cephalic index, the facial index, the nasal index, the index of sitting height, the arm length (shoulder height minus dactylic height) and the index of arm length are given in italics in the appendix tables. The descriptive characters are given as recorded and will be discussed in a later section.

GENERAL BODY FORM

I. Stature (Table 1). The Hawaiians are a tall people. The mean height of the males, 171.3 cm., places them in the same class with the Tahitians (173.3),[1] the Samoans (171.7) and the Marquesans (174.3) and it is with these groups that they are most nearly related racially. They are only slightly shorter than the white population of the United States (171.9), and approach closely the height of the taller North American Indians (Sioux 172.4). The females are shorter, averaging 162.6 cm., or 94.9 per cent of the male height. The sexual difference in height is rather less than that observed among races of similar height.

The frequency distributions of these samples of the Hawaiians are given in Table 1. The height measurements have been grouped in two centimeter classes; but, even under this treatment, the graduation is not good and the distributions are irregular and give a poor approximation to a normal curve. Distinct indications of bimodality are absent, and it is probable that the irregularities are due to paucity of numbers rather than to the presence of more than one racial type in respect to stature. That the material studied is homogeneous is witnessed further by the comparatively short range of variation in height, 26 cm. in both sexes, and by the values of the dispersion measures, standard deviation and coefficient of variation. The coefficient of variation is the more suitable for use in comparing these Hawaiians with other races, since it is stated in per cent and not in terms of the particular unit of measurement used. Its value for the height of Hawaiian males

[1] Comparisons are made, unless noted to the contrary, with data compiled by Martin (13).

TABLE 1. PURE HAWAIIANS. STATURE (WITHOUT SHOES)

	Seriations																		Total	Mean	S. D.	C. V.
Cm.	150–151.9	152–153.9	154–155.9	156–157.9	158–159.9	160–161.9	162–163.9	164–165.9	166–167.9	168–169.9	170–171.9	172–173.9	174–175.9	176–177.9	178–179.9	180–181.9	182–183.9	184–185.9	..	....	....	....
Males	...	...	...	...	...	2	...	7	10	10	16	7	4	6	4	2	1	1	70	171.31 ±0.40	5.00 ±0.28	2.92 ±0.17
Females	1	...	3	3	...	5	9	6	5	1	...	...	1	...	...	...	...	...	34	162.59 ±0.59	4.68 ±0.38	2.88 ±0.23

TABLE 2. PURE HAWAIIANS. SITTING HEIGHT

	Seriations																Total	Mean	S. D.	C. V.
Cm.	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	..	....	...	....
Males	...	..	1	2	3	5	7	5	10	8	11	7	5	0	2	3	69	90.11 ±0.24	2.95 ±0.17	3.27 ±0.19
Females	1	4	2	3	5	6	5	2	3	1	1	1	..	..	..		34	86.35 ±0.31	2.66 ±0.22	3.08 ±0.25

TABLE 3. PURE HAWAIIANS. INDEX OF SITTING HEIGHT

	Seriations															Total	Mean	S. D.	C. V.
Per cent	49.5 49.9	50.0 50.4	50.5 50.9	51.0 51.4	51.5 51.9	52.0 52.4	52.5 52.9	53.0 53.4	53.5 53.9	54.0 54.4	54.5 54.9	55.0 55.4	55.5 55.9	56.0 56.4	56.5 56.9	..	....	....	....
Males	2	3	5	4	3	10	11	12	11	6	..	..	1	1	..	69	52.61 ±0.11	1.38 ±0.08	2.62 ±0.15
Females	..	..	2	4	3	2	5	5	4	3	1	3	1	..	1	34	53.13 ±0.17	1.51 ±0.12	2.84 ±0.23

is but slightly greater than 2.9 per cent. This does not differ significantly from the variability of 3.05 per cent for Samoan males as determined by Sullivan (11). It is significantly less than the variability of pure Sioux males — 3.3 per cent (Sullivan 12) and of the modern Egyptians studied by Craig (9), the variability of various groups of the latter (comprising over 9000 individuals) ranging from 3.26 to 4.43 per cent. The Hawaiians are less variable in height than either of the last named homogeneous types.

II. Sitting Height (Table 2). The mean absolute value of this measurement is of significance only as a record. Its chief importance lies in its indication of bodily proportion and it must thence be stated as a percentage of the total stature. The data are presented in this form in the next section.

The frequency distribution itself shows a greater irregularity, a greater relative range and a higher variability than does the distribution of total stature. This may be due in part to the inherent error of the observation,[1] but a portion of the increased variability is probably real, since other segments of stature not susceptible to such error, show the same increase in variability. This conclusion is borne out by a comparison of the Hawaiians with the large series of Sioux studied by Sullivan (12). The coefficient of variability of sitting height of the Sioux males is 3.95 per cent, which is greater than the variability of the same measurement in the Hawaiians (3.27 per cent), and greater also than the variability of the Sioux in total stature (3.3 per cent). We have found no comparable data on the sitting height of other Polynesian peoples. The mean sitting height of the females is 95.8 per cent of the mean sitting height of the males. Thus the sexes differ less in sitting height than in total stature.

III. Index of Sitting Height (Table 3). This index gives the sitting height as a proportion of total height and is an indication of the relative length of the trunk as compared with the rest of the body. The races of mankind in which this proportion has been studied differ relatively little in this respect. Its value ranges from a mean of 46.5 in the long legged Australians to slightly over 54 in Ainos and certain negroes (BaBinga). The Hawaiians fall in about the center of the range with a mean relative trunk

[1] Sitting height is difficult to measure accurately because of the varying thickness of fat and integument on the buttocks.

length of 52.6 for the males and 53.13 for the females. The sexual difference in this index is not significant. The individual differences in respect to this index among the Hawaiians are relatively small, as can be seen in the frequency distribution in Table 3. Of the males 44 or 63.8 per cent are characterized by indices between 52 and 53.9. It is an extremely compact distribution and is markedly asymetrical. The frequency curve descends slowly from the mode toward the lower limit of 49.5 and very rapidly toward the upper limit of 56.9. It would appear from this that the limit of variation in the direction of short leggedness is much more rigid than in the opposite direction. A negative skewness indicates that the same is true of the sitting height index in Sioux males.

The variation constants for this index are lower than those for any other of the physical characteristics of the Hawaiians, although the differences between stature and sitting height in this respect are probably not significant.

IV. Height of Shoulder (Table 4). This measure is chiefly of value in determining the absolute and relative arm length, by subtraction from it of the dactylic height. The distribution in its irregularity and variability resembles that of sitting height. In this segment the variability also exceeds that of the total stature.

The mean shoulder height of the females is 95 per cent of that of the males, a sexual difference similar to that noted in sitting height. The variability of the two sexes is the same and there is no sexual difference in the proportion of shoulder height to stature (males 81.8 per cent, females 81.9 per cent).

V. Length of Arm (Table 5). The length of arm in the Hawaiians (acromion to dactylion III) varies through a rather wide range, 21 cm. in the males and 14 cm. in the females. The mean is 77.76 cm. in the males, 72.07 cm. in the females. The arm length of the Hawaiians is practically the same as the arm length of the Siouan tribes (Sioux males 77.0 cm., females 71.8 cm.). In the male distribution there is some indication of a positive skewness while the small numbers in the female distribution preclude a comparison on this point. Certainly, however, this is the most variable of any of the bodily measurements yet considered. Much of this variability may be accounted for by the fact that it is an indirect measurement, liable to error (possibly cumulative) from two sources — the acromic and the dactylic measurements — neither of which is entirely accurate.

TABLE 4. PURE HAWAIIANS. HEIGHT OF SHOULDER.

	Seriations																			Total	Mean	S. D.	C. V.
Cm.	123	124.5	126	127.5	129	130.5	132	133.5	135	136.5	138	139.5	141	142.5	144	145.5	147	148.5	150	...	....	....	....
Males	...	...	...	...	...	...	5	3	8	7	10	15	5	3	2	4	4	2	2	70	140.12 ±0.37	4.57 ±0.26	3.26 ±0.19
Females ..	1	...	3	3	1	5	5	5	5	2	2	1	...	...	1	...	...	...	...	34	133.10 ±0.50	4.32 ±0.35	4.32 ±0.26

TABLE 5. PURE HAWAIIANS. ARM LENGTH

	Seriations																						Total	Mean	S. D.	C. V.
Cm.	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88	..	....	....	....
Males	..	..	1	..	..	4	4	7	9	9	7	4	4	5	6	3	4	..	..	1	..	1	69	77.76 ±0.29	3.63 ±0.21	4.67 ±0.27
Females ...	4	1	2	5	4	5	8	..	1	1	..	..	1	1	..	..	..	..	..	..	..	..	33	72.07 ±0.35	3.00 ±0.25	4.17 ±0.35

The sexual differences in this measurement are somewhat greater than in the other bodily measurements, since the female mean is but 92.7 per cent of the male. The males are apparently somewhat more variable in respect to arm length.

VI. Index of Arm Length (Table 6). The ratio of arm length to total height is 45.28 per cent for Hawaiian males and slightly less (44.33 per cent) for Hawaiian females. The means for Sioux males and females are 44.6 and 44.9 respectively. The distribution of this proportion is irregular in both sexes, although the total range of variation is very small (42 to 48 per cent in males; 41.5 to 46 per cent in females). This range of variation resembles the variation in racial means for this character in all races measured since the mean index varies only from 43.2 for Japanese to 48.5 for certain pygmy races. The variability of the index as measured by the coefficient of variability is likewise low—3.34 for males; 3.27 for females as compared with 3.29 and 3.75 for Sioux males and females. As in the case of sitting height, the proportion is much less variable than the absolute dimension, indicating correlation between the part and the total stature. In the case of arm length the correlation with stature is very high (0.80 ± 0.03). It is noteworthy that a dimension of the appendicular skeleton should show a closer relation to height than actual segments of height, such as sitting height.

VII. Body Weight. The weights of a portion of the subjects were obtained, the measurements being recorded to the nearest pound, and in some cases, to the nearest five pound class. The distribution of weight in each sex was highly variable and irregular. Because of the small size of the sample, and the error attending the observations (variability of clothing, coarseness of the unit of measurement, etc.) the data are thought not to be comparable in accuracy to the measurements given above. They have, therefore, not been given statistical treatment. We have been content to calculate the averages for a series of 60 adult males and 16 adult females. The averages are: males 170.3 pounds (7726 grams); females 153.1 pounds (6942 grams). These averages place the Hawaiians among the heavier races of men. The index of bodily fullness $\frac{\text{weight} \times 100}{\text{stature}^3}$ has been calculated from the weight and statures of the sixty male subjects for which both measures are available and has been found to be 1.53 which is considerably

Table 6. Pure Hawaiians. Index of Arm Length

	Seriations														Total	Mean	S. D.	C. V.
Per cent	41.5	42	42.5	43	43.5	44	44.5	45	45.5	46	46.5	47	47.5	48	..	....	....	....
Males	..	2	..	4	3	6	14	7	11	9	3	6	3	1	69	45.28 ±0.12	1.51 ±0.09	3.34 ±0.19
Females	2	..	2	4	4	8	4	4	2	2	..	..	..	..	32	44.33 ±0.17	1.45 ±0.12	3.27 ±0.27

Table 7. Pure Hawaiians. Head Length

	Seriations											Total	Mean	S. D.	C. V.
Mm.	162	166	170	174	178	182	186	190	194	198	202	..	....	....	....
Males	2	3	4	14	14	13	8	7	3	5	1	74	182.42 ±0.70	8.90 ±0.49	4.89 ±0.27
Females	1	3	7	3	10	4	2	1	2	1	...	34	178.79 ±0.97	8.43 ±0.69	4.71 ±0.39

higher than the averages for the males of European races [Martin (13), p. 248]. This tendency toward bodily fullness (stoutness) has been noted by many observers of the Hawaiians and other Polynesians and has been frequently attributed to their diet, mode of life and admiration for corpulence. In view of Davenport's recent investigations (15), however, the Hawaiians may have an inherent racial tendency toward stoutness.

Conclusions from Bodily Dimensions. On the whole, the means of the main bodily dimensions of living Hawaiians accord well with those given for other Polynesians (cf. Martin (13); Deniker (20); Sullivan (11)). The measures of variation (range, standard deviation, coefficient of variation) are of the same order of magnitude as those obtained from larger samples of other well defined races, for example with those of the 697 pure Siouan subjects collated by Sullivan (12). Wherever significant differences occur, these are found to be in the direction of lesser variability and greater homogeneity on the part of the Hawaiians.

CEPHALIC AND FACIAL CHARACTERISTICS

I. Head Length (Table 7). (a) *Distribution.* The graduation of this distribution is fairly regular for the males and poor for the females even with the rather coarse class intervals of 4 mm. which it has been necessary to use. Variation in head length has usually been found in larger samples of other races to be described by a normal curve of error and our data approximates this type although a slight positive skewness is in evidence. The male curve is monomodal and a large majority of the individuals fall in the modal and two greater classes. The female curve shows some evidence of bimodality in the concentration of frequencies in the classes 170–173 and 178–81, although in view of the small numbers this is probably not significant.

(b) *Mean.* The mean head length of the males is 182.42 mm., of the females 178.79 mm., giving a sexual difference of 3.63 mm., which is barely significant. The female head length is about 98 per cent of the male length, indicating relatively less difference in this respect than between the sexes of other races.

These mean head lengths are to be compared with other Polynesian material as follows:

Table 7a. Comparative Data on Cephalic Features of Polynesian Peoples

	No.	Sex	Head length	Head breadth	Cephalic index	Authority
Hawaii.......	74	M	182.4	152.0	83.4	This paper
Samoa........	68	M	190.6	154.8	81.3	Sullivan (11)
Tonga........	95	M	191.0	154.8	81.1	" (11a)
Marquesas	84	M	193.2	153.2	79.4	" (11a)
Hawaii.......	18	M	185.8	139.1	77.3[2]	von Luschan (16) Crania
Hawaii.......	135	M&F	175.2	139.8	81.7[2]	Otis (19) Crania[1]

[1] Chiefly from Kaui but including a few from Maui.
[2] Cephalic index derived from cranial index by means of Craig's correction (addition of 2.5 units to cranial index).

The first five series refer to present inhabitants and are probably comparable. They differ somewhat, but agree in showing a significantly greater head length than the earlier data for crania of previous inhabitants. A portion of this may be due to a difference in the technique of measurement. The racial classification of the cranial series is less certain than that of the living subjects, and evidence from the former is less reliable.

(c) *Variability.* Both measures of variability are very high when compared with the same constants for other races as listed below:

Race	No.		Standard Deviation (mm.)		Coefficient of Variation (%)		Authority
	♂	♀	Male	Female	Male	Female	
Hawaiian	74	34	8.90	8.43	4.89	4.71	This paper
Samoan...........	68	23	5.69	5.22	2.98	2.85	Sullivan (11)
Egyptian (19 dists.)	9892[1]		5.09–6.65[2]		2.95–3.49[2]		Craig (9)
Sioux............	539	156	6.16	5.09	3.16	2.72	Sullivan (12)

[1] Males only. [2] Range by districts.

No standard deviation for head length as high as that found for our Hawaiian series is listed by Martin (13, p. 705) for eight races.

The range of variation of the Hawaiians is likewise very great. The comparative data for males only are given below:

Race	No.	Range (mm.)	Authority
Hawaiian	74	41 (162–203)	This paper
Samoan	68	29 (174–203)	Sullivan (11)
Marquesan	84	32 (178–210)	Sullivan
Hawaiian (skulls)	60	32 (162–194)	Allen (17)
Hawaiian (skulls)	18	20 (175–195)	von Luschan (16)
Tongan	95	37 (176–213)	Sullivan
Hawaiian	109	30 (163–193)	Otis (19)

In general our series shows a greater range of variation in head length than any of the other series quoted. Its lower limit coincides with Allen's skull series, and its upper limit with Sullivan's series from Samoa. The technique used in the measurement of our own and Sullivan's subjects was the same, and this comparison is the more enlightening. The chief difference here is the presence of a number of absolutely short headed subjects with head lengths of 162–174 mm. in our series and their complete absence from Sullivan's series. All of these shorter headed individuals appear in the series measured in 1920. The range of the subjects in the 1916 series was from 174–203, and is identical with Sullivan's Samoan series. The abnormally high range and variability in the head length of our whole series appear to be due to the addition of about 12½ per cent of very short headed subjects in the data secured in 1920. All except two of these short headed subjects were stevedores and half of them came from the island of Maui. Both of these groups have somewhat shorter heads than the general Hawaiian population (33 stevedores average 177.7, 10 males from Maui average 177.0, general average 182.4), so we are unable to decide whether the difference is racial or due to occupational selection.

The slight difference in variability existing between the sexes in respect to head length is not significant in the present sample.

II. **Head Breadth** (Table 8). (*a*) The distribution of head breadth in both sexes is in general similar to the distribution of head length. The graduation is irregular, though in general the curve is smoother than that for head length. A positive skewness is in evidence in the distributions of both sexes, slight in the females, more pronounced in the males. Both distributions are undoubtedly monomodal, indicating that in all probability the different head breadths encountered are variations of one main type.

(*b*) The mean of this type is 152.03 mm. for the males and 150.26 mm. for the females. The sexual difference is 1.77 ± 0.81 mm., which indicates that in the subjects measured the heads of females were not significantly narrower than those of the males. The female width is 98.8 per cent of the male width. For comparison we may refer to Table 7a above. The head breadth of the Hawaiians of our series agrees closely with the head breadth of living Samoans, but is considerably greater than the head breadth of the earlier series of crania.

(*c*) Head breadth in these subjects, as is in general the case, is less variable both relatively and absolutely than head length (the coefficient of variation for the males is 3.80). Nevertheless the constants of variation are extremely high for an island people. The Hawaiians are more variable in head breadth than the Samoans reported by Sullivan (11) (coefficient of variation for males 2.88). The coefficient of variation of head breadth of modern Egyptians (Craig (9)) varies in districts from 3.04 to 3.59 per cent. For Sioux Indians Sullivan (12) gives the variability for females 3.47, males 3.20. Martin lists variabilities in head breadth for eight races. The male values range from 2.76 (Aino) to 4.21 (French); females from 2.47 (Tasmanians) to 3.78 (English). These Hawaiians are apparently more variable in head breadth than any races for which figures are given, with the exception of the composite English and French. The range of the Hawaiians in head breadth is 24 mm. (144–165) for the males and 23 mm. (138–161) for the females. This range is somewhat less than that met with in other racial groups, since the average range in head breadth of 13 races listed by Martin (p. 663) is about 29 mm. for males. The agreement between our data and the skull measurements in respect to range and variability of head breadth is no better than in the case of head length, but the comparability of the material is too uncertain to allow conclusions to be drawn concerning changes in the physical features of the Hawaiians.

The range of the 1916 subjects was from 148 to 165 mm. with a mean of 158.78 ± 0.45, while that of the 1920 subjects was from 140 to 163 with a mean of 150.01 ± 1.01. The difference between the means of the two series is 8.77 ± 1.10, which is eight times its error, and is undoubtedly significant.

TABLE 8. PURE HAWAIIANS. HEAD BREADTH

	Seriations										Total	Mean	S. D.	C. V.
Mm.	137	140	143	146	149	152	155	158	161	164	..	....	....	....
Males	...	4	4	13	18	10	10	8	6	1	74	152.03 ±0.45	5.77 ±0.32	3.80 ±0.21
Females	1	1	5	8	6	6	1	4	2	...	34	150.26 ±0.68	5.88 ±0.48	3.91 ±0.32

TABLE 9. PURE HAWAIIANS. CEPHALIC INDEX

	Seriations										Total	Mean	S. D.	C. V.
Per cent	74	76	78	80	82	84	86	88	90	92	..	....	....	....
Males	2	..	7	15	16	12	8	6	7	1	74	83.44 ±0.25	3.17 ±0.17	3.80 ±0.21
Females	1*	1	2	5	9	5	6	4	1	..	34	84.16 ±0.45	3.92 ±0.32	4.66 ±0.43

* Actually 73.8.

TABLE 10. PURE HAWAIIANS. WIDTH OF FACE (BIZYGOMATIC DIAMETER)

	Seriations													Total	Mean	S. D.	C. V.
Mm.	123	126	129	132	135	138	141	144	147	150	153	156	159	..	....	....	....
Males	1	3	5	7	17	11	8	6	4	1	5	4	1	73	140.19 ±0.65	8.25 ±0.46	5.88 ±0.39
Females	1	2	8	4	3	4	5	5	1	1	..	..	..	34	136.71 ±0.79	6.87 ±0.56	5.02 ±0.41

III. Cephalic Index (Table 9). (*a*) The distribution of head shape as measured by the length-breadth index departs from the expected normal curve especially among the males. The positive skewness is greater than in either the length or breadth measurements and the distribution appears truncated at the dolichocephalic end. Only two males and one female can be said to be dolichocephalic (index under 75.9). Forty-three males (58 per cent) and 19 females (56 per cent) are grouped in the relatively short space of three classes from 80–85.9. In the males the main part of the curve, i.e. about 78, is monomodal, and the two dolichocephalic individuals are separated from the main distribution by a zero class, indicating a possibility that they may be discontinuously variable from the rest of the subjects and a distinct type. The same is true of the one female dolichocephal.

(*b*) The mean cephalic index plainly places these Hawaiians among the brachycephalic races. The mean cephalic index for related races is given in Table 7a.

The females, as is generally the case, are slightly shorter headed than the males, the sexual difference in mean index being 0.8 per cent; or the male index is about 99 per cent of the female.

(*c*) Variability. All types of head shape were encountered among these Hawaiians from dolicho to extreme brachycephalic. The actual range of indices (males) was from 74 to 93 per cent, which is quite similar to the range of the related Samoan males 74–89 per cent (Sullivan). The concentration of head shapes in the brachycephalic part of the range is chiefly responsible for the rather low value of the dispersion measures. Data from other representative racial types are given below:

Group	No. of Cases	Sex	Coefficient of Variation (%)	Authority
Hawaiians..........	74	Male	3.80	This paper
Samoans............	68	"	4.34 [1]	Sullivan (11)
Egyptians..........	9892	"	3.06–4.35	Craig (9)
Sioux...............	537	"	4.03 [1]	Sullivan (12)

[1] These constants have apparently been calculated from the arrays of indices without regard to the correlation between the components of the index. This produces a somewhat higher apparent variability than the method employed in this paper. Cf. p. 97.

The conclusion seems warranted that, although extremely variable in the absolute dimensions of the head, the Hawaiians measured are relatively conservative and constant in head shape. It probably follows that the variability found in the absolute dimensions was due to variation in the degree of growth attained, nourishment, etc. rather than to a mixture of types of head form.

The females were somewhat more variable in head form than the males, although the difference is not certainly significant.

IV. Maximum Width of Face (Bizygomatic Diameter). Table 10. (*a*) The frequency curve of variation in width of face is normal for the males between the classes 123–150. The graduation is regular, a single mode is in evidence, and there is only a slight negative skewness. But above the class 150 there is a distinct tendency toward the formation of another mode about the class 153. The ten subjects with very wide faces occur in the 1916 data. They resemble the other 1916 subjects in being much larger in all cephalic and facial dimensions than any of the 1920 subjects. The female frequencies are irregular and the curve describing their variation in facial width appears also to be bimodal, as though the larger group were made up of two or more groups differing in width of face.

(*b*) The mean width of face (males 140.19 mm., females 136.71 mm.) places these Hawaiians among the broader faced races. This dimension ranges in average value for the various races for which data are available from 116 to 153 mm. (Martin, p. 793); The Hawaiians fall in the upper part of the range together with other Polynesians and with the Mongoloid types in general. They agree in this character with the Samoans (males 145.9 mm., females 136.5 mm.). We have not found other comparable data for Polynesians.

The sexual difference in face width is greater than in the other head characters measured, and is statistically significant. The female bizygomatic diameter is 97.5 per cent of the male diameter.

(*c*) The variability of the Hawaiians in face width is very great. The coefficient of variation for the males is 5.88 per cent as compared with 3.59 per cent for the face width of Samoan males and 3.65 for Sioux males. The males are somewhat more variable than the females.

V. Anatomical Height of Face (Nasion-Menton Height). Table 11. (*a*) A repetition of all of the remarks made concerning face width would serve equally well for face height. There is a tendency toward bimodality in the upper part of the range in both sexes.

(*b*) The mean values indicate that these Hawaiians have not only very broad but also very high faces. Racial averages for this trait vary from 103 to 131 mm. (males, Martin, p. 793), and the Hawaiians with a mean height of 122.72 mm. are near the upper limit of inter-racial variation. They resemble the closely related Samoans who have a face height of 131 mm., the greatest racial value for this trait which I have found. The faces of the Hawaiians are therefore absolutely large and massive, although smaller than those of the Samoans. The sexual difference in this dimension is marked and significant, the female face averaging only about 94.7 per cent as high as the male.

(*c*) The variability in height of face is the same as the variability in width of face. This group is more variable in face height than the Samoans (C. V. males 5 per cent), or the Sioux (C. V. males 5.12 per cent). The variability of the sexes is, in view of the probable errors involved, about the same.

Data for the nasion-prosthion height are also given (Table 12), but call for no discussion since this measurement enters into none of the proportions used.

VI. Facial Index (Table 13). (*a*) The distribution of the index measuring the shape of the face is continuous and fairly regular in the males, and in spite of the tendency towards the formation of minor modes in the curves of variation in face width and height, the curve describing variation in shape of face has but one mode, and this falls in the same class (86–87.9 per cent) with the mean. Variation in shape of face appears to be described by a normal curve of error, indicating a degree of homogeneity in the material.

(*b*) The mean indices (males 87.67 per cent, females 85.07 per cent) indicate an average meso- to leptoprosopic type, although all types of face form were encountered. Of the males 17 or about 23 per cent had relatively broad euryprosopic faces (index below 84), 22 or about 30 per cent fell in the meso group, 24 or nearly 33 per cent were leptoprosope, while the remainder or about 14 per cent had extremely narrow faces of the hyperlepto type (index

Table 11. Pure Hawaiians. Height of Face (Nasion-menton)

	Seriations														Total	Mean	S. D.	C. V.
Mm.	101	104	107	110	113	116	119	122	125	128	131	134	137	140	..	....	....	....
Males	..	1	..	4	6	8	16	13	10	4	7	1	2	2	74	122.72 ±0.57	7.22 ±0.40	5.88 ±0.39
Females	1	..	6	1	11	3	2	5	5	..	..	..	..	..	34	116.21 ±0.75	6.48 ±0.53	5.58 ±0.46

Table 12. Pure Hawaiians. Nasion Prosthion Height

	Seriations													Total	Mean	S. D.	C. V.
Mm.	58	60	62	64	66	68	70	72	74	76	78	80	82	..	....	....	....
Males	..	1	3	9	11	6	14	10	6	5	5	3	1	74	71.16 ±0.40	5.06 ±0.28	7.11 ±0.40
Females	3	4	4	5	6	3	4	3	2	..	..	..	..	34	66.47 ±0.53	4.60 ±0.38	6.92 ±0.57

Table 13. Pure Hawaiians. Facial Index

	Seriations														Total	Mean	S. D.	C. V.
Per cent	74.0	76.0	78.0	80.0	82.0	84.0	86.0	88.0	90.0	92.0	94.0	96.0	98.0	100	..	....	....	....
Males	1	..	4	5	7	6	16	12	11	3	4	2	1	1	73	87.67 ±0.41	5.18 ±0.29	5.91 ±0.33
Females	..	1	2	5	4	8	7	5	..	2	..	..	..	..	34	85.07 ±0.45	3.93 ±0.32	4.62 ±0.38

above 93). In mean and distribution they resemble the Samoans (average index 89.9) although they have relatively as well as absolutely somewhat narrower faces than the Samoans. The females had significantly broader faces than the males, the female index being about 98 per cent of the male.

(*c*) The chief peculiarity of variation in the shape of the face is the extremely wide range through which the index varies. The range is (male) from 74 to 100, and includes the whole range of racial face shapes so far encountered among the races of men. (The range of racial means as collated by Martin, p. 796, is only from 80 to 97.2 per cent.) The variability measures are not, however, banormally high. The coefficient of variability (males 5.91) is but slightly greater than the same constant for Samoan males (5.42), and less than that of Sioux males (7.58). This is probably due to the clustering of frequencies about the modal value, since over 61 per cent of the male subjects had indices between 84 and 92.9.

The males were more variable than the females in shape of face.

VII. Nasal Height, Breadth and Shape (Tables 14–16). (*a*) The measurements of these soft parts are much less accurate than the data for other characteristics described; and, aside from general indications, call for little discussion. Variation in height of nose is the most regular, but there is little approach to a normal curve in any of these dimensions. All are characterized by a wide range and higher variation constants than any of the other facial or cephalic measures.

(*b*) In mean height and breadth of nose the Hawaiians resemble the Samoans, although the nose is absolutely shorter, and the index, which measures the shape of the nose, significantly higher than that of the Samoans (Hawaiian males index 82.9; Samoan males 73.6). The Hawaiian nose is typically mesorrhine and relatively broader than the Samoan. Only the broader types of nose were found, no true leptorrhine types occurring in our sample. Seventy per cent of the subjects were mesorrhine, and the remainder were chamaerrhine, except for two subjects with indices of 100 and 102. The males appeared to have somewhat larger and relatively broader noses than the females.

(*c*) Variation in the dimensions and shape of the nose is high. The variation constants are in general greater than for the corresponding measurements of the Samoans, and less than those of the Sioux.

TABLE 14. PURE HAWAIIANS. NASAL HEIGHT

	Seriations											Total	Mean	S. D	C. V
Mm.	43 44	45 46	47 48	49 50	51 52	53 54	55 56	57 58	59 60	61 62	63 64	..	....	....	...
Males	..	3	2	13	13	12	10	7	8	4	2	74	53.59 ±0.32	4.12 ±0.23	7.69 ±0.43
Females	2	3	6	5	7	4	4	3	..	..	..	34	51.23 ±0.45	3.90 ±0.32	7.61 ±0.62

TABLE 15. PURE HAWAIIANS. NASAL BREADTH

	Seriations																		Total	Mean	S. D.	C. V.
Mm.	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	..	....	....	....
Males	..	..	..	1	2	1	8	10	8	13	9	8	4	6	1	..	2	1	74	44.22 ±0.22	2.80 ±0.15	6.32 ±0.35
Females	1	..	1	5	6	4	6	3	1	3	1	..	1	1	1	..	..	..	34	40.94 ±0.36	3.09 ±0.25	7.55 ±0.62

TABLE 16. PURE HAWAIIANS. NASAL INDEX

	Seriations																		Total	Mean	S. D.	C. V.
Per cent	68	70	72	74	76	78	80	82	84	86	88	90	92	94	96	98	100	102	..	....	....	....
Males	2	3	6	8	3	7	10	7	4	4	5	3	6	2	1	1	1	1	74	82.94 ±0.61	7.73 ±0.43	9.32 ±0.52
Females	..	3	4	3	4	5	2	..	2	4	4	1	1	..	..	..	..	1	34	80.38 ±0.83	7.20 ±0.58	8.96 ±0.74

Conclusions from Data on Dimensions of Head and Face. The data on the dimensions and shape of the head and face of the Hawaiians agree fairly well with Sullivan's descriptions of the Samoans, but not with previous observations on Hawaiians, derived from cranial material. The heads measured were large and predominantly brachycephalic. Only three subjects were found to be dolichocephalic, and these appeared to be discontinuous variates from the rounder headed type. The Hawaiian faces were found to be broad and massive like those of Mongoloid peoples. The dimensions and shape of the Hawaiian face are similar to those of the Samoan, but are somewhat narrower and less massive.

The absolute dimensions of both head and face appeared to be abnormally variable; while the range, distribution and dispersion measures of the shape indices were not abnormal, but indicated rather a degree of homogeneity in the material. This difference is interpreted as due to a considerable environmental variation in growth as expressed in the absolute dimensions, while the form attained may be regarded as innate or racial. As we concluded from the comparison of bodily proportions, these presumably racial traits are relatively conservative in variation in the Hawaiians measured, and they may be regarded as a fairly homogeneous group racially.

NON-MENSURABLE, PHYSICAL CHARACTERISTICS OF THE HAWAIIANS

Several of the physical traits of the Hawaiians which are not susceptible of exact mechanical measurement were classified roughly and entered on the schedules. The descriptive terms used are explained on p. 94. Such traits included hair color, hair form, eye color, skin color, nose form, incidence of the Mongolian (epicanthic) fold and of prognathism. For a portion of the subjects, descriptions of eyebrows, brow ridges, forehead, malars, face shape, lips, chin, teeth and ears were also obtained, but the records are thought to be too scattered and difficult of classification to contribute materially to this description of the Hawaiians.

I. Hair color (Table 17). Although few grades of hair color were distinguished, this characteristic apparently varies but little among the one hundred and fifty-four subjects observed. Ninety-one per cent of these Hawaiians had black hair. About six per

Table 17. Distribution of Hair Color in Pure Hawaiians

Color	White	Reddish Brown	Brown	Dark Brown	Black	No Record	Total
Frequency	1	2	1	9	141	3	157

cent of the subjects had dark brown hair, while only three or less than two per cent had hair of a lighter shade. Of these two had distinctly reddish hair. This variation is qualitatively different from the normal black or dark brown pigmentation, and the red haired subjects probably represent a recessive blonde type introduced originally by a remote cross with a European race. These subjects were typically Hawaiian in their other traits, and there is no reason for questioning their immediate pedigrees. Such reddish brown hair is occasionally seen on persons regarded as pure Hawaiian and designated by the native name Ehu. There is no reason to believe that their blood is not as pure as that of the darker haired natives and they should be included in a description of the Hawaiian type.

II. Hair form (Table 18). It is in hair form that the Hawaiians depart most widely from the uniformity which one might expect

Table 18. Distribution of Hair Form in Pure Hawaiians

Form	Straight	Wavy	Curly	Frizzy	Crinkly	Kinky	No record	Total
Frequency	13	92	44	3	2	1	2	157

in an island race. The predominant forms are plainly wavy and curly, themselves quite variable and intergrading with each other. To the general wavy-curly type may probably be assigned also the kind of straight smooth hair which occurs among the Hawaiians. The Hawaiian straight hair is very similar in texture to the wavy type and continuous intergradations connect the two types. It is not to be confused with the heavier, straighter and coarser Mongolian type of straight hair. All except six of the one hundred and fifty-five subjects fell in one of these three related classifications, the most frequent hair type being wavy (fifty-nine per cent). Three individuals were reported as having frizzy, two crinkly, and one kinky hair — variations in hair form which are in the opposite direction from straight. These forms, on account of their rarity and the greater change they involve in hair form, are much less likely to be normal to the Hawaiian type. All six were females, and it is possible that in some of the subjects artificial deformation of the hair may have disguised its true form. One " kinky " subject departed seriously from the average in arm length, while the observer noted of one of the girls described as " crinkly " haired that she " looked like a Negro." The observer, in absence of other evidence to the contrary, accepted them as Hawaiians, and although it is likely that one or two may have some negro blood, we have included them in the Hawaiian series. Their omission would cause no significant change in the averages of the physical characteristics of Hawaiian females.

III. Eye color (Table 19). Eye color, like hair color, varied but little among the one hundred and fifty-six subjects observed. The

Table 19. Distribution of Eye Color in Pure Hawaiians

Color	Very Light	Brownish Blue	Light Brown	Brown	Dark Brown	Very Dark Brown	No Record	Total
Frequency......	1[1]	1	18	67	61	7	2	157

[1] Recorded as "almost blue."

eyes of all except two were some shade of brown, the classes medium and dark brown including seventy-eight per cent of the whole group. The individual recorded as " brownish blue " was typically Hawaiian in other respects and was entered as " Ehu." This case may be interpreted as a further instance of segregation of the recessive blonde Ehu type, this time with respect to eye color only, since the hair was dark brown. The other exception described as " almost blue " in eye color may be a quantitative variant from the brown type or a segregate from an earlier cross. In other traits he agreed with the Hawaiian type.

IV. Skin color (Table 20). The descriptions of the skin color of these Hawaiians are admittedly approximate and, in the only

Table 20. Description of Skin Color

Grade No.	von Luschan's Scale Frequency		Grade No.	Broca's Scale [1] Frequency	
	Male	Female		Male	Female
11	1	1	47	2	15
12	1	1	23	2	12
13	..	2	..	..	..
14	1	3	24	6	23
15	2	3	39	5	..
16	..	2	25	2	1
17	..	2	40	5	2
18	1	..	..	..	..
19	1	..	..	..	..
Total	7	14	..	22	53

[1] The grades of Broca's scale have been placed opposite similar grades on von Luschan's scales. The colors in the two scales are not of the same quality, and it is unwise to combine observations recorded on the two scales.

form in which it was practicable to collect such data, not susceptible of quantitative treatment.

The 1916 series of fifty-three females and twenty-two males were described in terms of Broca's scale as reprinted by Hrdlicka (1904). Most of the subjects had skin colors corresponding to Broca's numbers 24, 47, and 23. The modal grade for both sexes was 24. Only three females had skin colors darker than 23 (grades 25 and 40). The males had in general somewhat darker skins than the females. Twelve or nearly half of them were described by the grades 25, 39, and 40. In 1920, von Luschan's better scale was used, and although only twenty subjects (six males and fourteen females) were described on this scale, the results agreed well with the earlier descriptions. On von Luschan's scale, the skin colors varied from grade 11 to grade 19, the modal grades being 14 and 15 which, aside from the yellow or red component of the color, are about equivalent to Broca's grade 24. The average skin color of the Hawaiians is apparently a light yellowish or reddish brown — of about the tone of *café au lait.*

V. Nose form (Table 21). In addition to the data yielded by measurements of the nose, descriptive notes were made of the

Table 21. Description of Nose Form — Pure Hawaiians

	Root		Bridge			Septum		
	Normal	Depressed	Straight	Concave	Convex	Straight	Down	Up
Males	46	27	43	14	15	40	2	31
Females	11	20	15	9	5	14	1	16

general form of the nose with especial reference to root, bridge, and septum. The records were made in the terms used in Table 21. The root of the nose was found to be more frequently normal than depressed in the males; but in two-thirds of the females the root was depressed. The form of the bridge was straight in about half the subjects in both sexes. Departures from the straight-bridged type were as frequently in the direction of convexity as toward the concave type. The septum was either straight or directed slightly upward, while in only three subjects did it slope downward.

VI. Incidence of the Mongolian (epicanthic) fold. Out of one hundred and fifty-eight subjects observed, only four were found to exhibit this peculiarity of the eyelids, and in these subjects it was described as slight. Although it is somewhat difficult to distinguish this trait in the reduced form in which it occasionally appears, we feel fairly safe in saying that the typical Mongolian fold does not occur among the Hawaiians.

VII. Incidence of Prognathism. Observations of twenty-two adult males and fourteen adult females with special reference to prognathism indicate it is absent in the majority of the Hawaiians observed. Slight prognathism was noted in two males and four females.

VIII. Other traits. Observations of other traits listed on the schedule (p. 93) were made on a portion of the subjects observed in 1916. A brief summary of the more important of these is given below. Only adult subjects are included.

(*a*) Brow ridges:

Classification	Males	Females
Absent	..	14
Present	2	..
Slight	7	3
Prominent	11	..
Total	20	17

(*b*) Thickness of lips:

Classification	Males	Females
Medium	11	9
Thick	9	8
Total	20	17

(*c*) Strength as measured by grip of hand (recorded in kilograms).

	Right Hand		Left Hand	
	Males	Females	Males	Females
Number	58	30	19	17
Average	53.8	29.8	52.6	26.3

(*d*) Forehead:

Height			Breadth			Slope		
Class	Males	Females	Class	Males	Females	Class	Males	Females
Low	1	1	Medium	15	15	Vertical	..	10
Medium	10	11	Broad	5	2	Slightly receding	9	4
High	9	5	....	..	..	Receding	10	3
						Low	1	..
Total	20	17	....	20	17	....	20	17

GENERAL CHARACTERISTICS OF THE HAWAIIANS

The general picture of the average Hawaiian which may be reconstructed from the foregoing description portrays a tall heavy individual, inclined to be stout; with limbs and trunk of medium length. The head is large, and both absolutely and relatively short. It is generally brachycephalic in shape. The face is both broad and high with prominent cheek bones, and its shape ap-

TABLE 22. MEANS AND VARIATION CONSTANTS FOR MEASUREMENTS OF LIVING HAWAIIANS

Dimension	Adult Males				Adult Females			
	No.	Mean	S. D.	C. V.	No.	Mean	S. D.	C. V.
Stature, cm.	70	171.31 ±0.40	5.00 ±0.29	2.92 ±0.17	34	162.59 ±0.54	4.68 ±0.38	2.88 ±0.23
Sitting height, cm.	69	90.11 ±0.24	2.95 ±0.17	3.27 ±0.19	34	86.35 ±0.31	2.66 ±0.22	3.08 ±0.25
Index of sitting height, %	69	52.61 ±0.11	1.38 ±0.08	2.62 ±0.15	34	53.13 ±0.17	1.51 ±0.12	2.84 ±0.23
Height of acromion, cm.	70	140.12 ±0.37	4.57 ±0.26	3.26 ±0.19	34	133.10 ±0.50	4.32 ±0.35	3.25 ±0.27
Arm length, cm.	69	77.76 ±0.29	3.63 ±0.21	4.67 ±0.27	33	72.07 ±0.35	3.01 ±0.25	4.17 ±0.35
Index of arm length, %	69	45.28 ±0.12	1.51 ±0.09	3.34 ±0.19	33	44.33 ±0.17	1.45 ±0.12	3.27 ±0.27
Head length, mm.	74	182.42 ±0.70	8.90 ±0.49	4.89 ±0.27	34	178.79 ±0.97	8.43 ±0.69	4.71 ±0.39
Head breadth, mm.	74	152.03 ±0.45	5.77 ±0.32	3.80 ±0.21	34	150.26 ±0.68	5.88 ±0.48	3.91 ±0.32
Cephalic index, %	74	83.44 ±0.25	3.17 ±0.17	3.80 ±0.21	34	84.16 ±0.45	3.92 ±0.32	4.66 ±0.43
Bizygomatic diameter, mm.	73	140.19 ±0.65	8.25 ±0.46	5.88 ±0.39	34	136.71 ±0.79	6.87 ±0.56	5.02 ±0.41
Nasion-menton height, mm.	74	122.72 ±0.57	7.22 ±0.40	5.88 ±0.39	34	116.21 ±0.75	6.48 ±0.53	5.58 ±0.46
Facial index, %	73	87.67 ±0.41	5.18 ±0.29	5.91 ±0.33	34	85.07 ±0.45	3.93 ±0.32	4.62 ±0.38
Nose height, mm.	74	53.59 ±0.32	4.12 ±0.23	7.69 ±0.43	34	51.23 ±0.45	3.90 ±0.32	7.61 ±0.62
Nose breadth, mm.	74	44.22 ±0.22	2.80 ±0.15	6.32 ±0.35	34	40.94 ±0.36	3.09 ±0.25	7.55 ±0.62
Nasal index, %	74	82.94 ±0.61	7.73 ±0.43	9.32 ±0.52	34	80.38 ±0.83	7.20 ±0.58	8.96 ±0.74
Nasion-prosthion height, mm.	74	71.16 ±0.40	5.06 ±0.28	7.11 ±0.40	34	66.47 ±0.53	4.60 ±0.38	6.92 ±0.57

proaches the square rather than the oval. The forehead is of medium height or higher, and in the male is generally receding. Brow ridges are present and frequently prominent. The nose is large and relatively broad and flat, although the root is more frequently of the straight European type than depressed as in negroid or Mongoloid races. The lips are but little thicker than among European races, and the teeth are usually very good. Prognathism is absent, and the chin is slightly receding.

The skin is light brown with a creamy or yellowish tinge. The hair is black, wavy or curly and generally abundant. The eyes are brown, large and straight as among Europeans.

I. Homogeneity of Type. As in all the races of men so far measured, all of these general traits as well as the various dimensions and proportions of the body and its parts are very variable. A comparison of one measure of variability for a number of traits of these Hawaiians with the corresponding traits for several other groups is given below (Table 23).

TABLE 23. COMPARISON OF THE COEFFICIENT OF VARIATION IN HAWAIIANS AND OTHER COMPARABLE GROUPS. MALES

	Hawaiian	Samoan	Sioux	South Chinese
Number	69–74	67–70	540	64
Stature	2.92	3.05	3.27	3.43
Head length	4.89	2.98	3.16	3.58
Head breadth	3.80	2.88	3.47	3.91
Bizygomatic diameter	5.88	3.59	3.65	3.24
Nasion-menton height	5.88	5.00	5.12	4.69
Nose height	7.69	6.09	6.75	....
Nose breadth	6.32	5.91	8.07	....
Cephalic index	3.80	4.34	4.03	....
Facial index	5.91	5.42	5.78	5.70
Nasal index	9.32	7.96	10.25	....

The Hawaiian series appears to be the most variable of all of the racial groups compared. It exceeds the Samoan group in variability of all except two of the traits given, viz., stature and cephalic index. It exceeds the Sioux series in all except four of the traits given; viz., stature, cephalic index, nose breadth and nasal index. It is more variable than the South Chinese series in head length, face breadth and height, cephalic index and facial index. The actual amount by which the Hawaiian exceeds the other series given is not great, except in the case of face breadth and not all of the differences in variability among these races are statistically significant. The excess in variability of the Hawaiians, while not great, is general and calls for some explanation.

Some of the reasons for the greater variability of the Hawaiians may be inferred from a comparison of the Samoans and Hawaiians. These two groups are strictly comparable in numbers, in race, in time and in technique of measurement. Both are from island populations which because of the greater amount of inbreeding brought about by isolation, are usually rather conservative in their physical traits. The chief difference between the Samoan and Hawaiian series is in their relative amount of recent contact with foreign stocks. The Samoans are to a greater degree unaffected by European or Oriental immigration and by the more complex social and economic conditions induced by the influx of foreign cultures. Their environment is less variable, and since many of the absolute dimensions of the body depend to some extent on the degree of growth attained, and thence on such environmental variations as nourishment, health, etc., it may be that their greater conservatism in physical traits is in part due to this fact. Greater social, economic and physical inequalities have been brought about in Hawaii by the introduction of more of the machinery of civilization, and this greater variability in the environment may induce a greater variability in the less stable physical characteristics. Wherever industrial methods are present, there is always the possibility of occupational variation in physical traits. In addition to this general cause of variation it has been already noted that our sample has been drawn chiefly from a few groups such as stevedores and factory workers and is probably more variable in size characters than a strictly random sample.

Contact with foreign stocks likewise produces the possibility of actual physical mixture between races, and such mixture leads generally to increased variability. We have tried to exclude from our Hawaiian series all progeny of recent crosses between Hawaiians and other races. We may, however, have included subjects descended from remoter crosses, and may thereby have obtained variabilities in excess of those normal to the race.

The values of the dispersion measures of the various traits are not however entirely reliable as guides in estimating homogeneity of type. They are greatly increased not only by environmental variation but by the presence of a few individuals which depart widely from the average, or by the departure of the distribution from the normal. The distribution itself, and the range of variation are better guides to homogeneity. Distinct evidences of bimodality are absent in the distributions of most of the Hawaiian traits. Even in such traits as head length, head breadth, face height and face breadth, in which the variability of the Hawaiians is greater than that of other groups, we find no evidence of the presence of more than one chief type. And since the proportions between these parts, especially in the case of the length-breadth index of the head, are relatively less variable, and show fairly normal and regular distributions, we may ascribe much of the variability in the dimensions to the degree of growth attained rather than to lack of homogeneity. The Hawaiian group as a whole then, while somewhat more variable than we might expect a pure island race to be, has none the less a unity which argues a large amount of antecedent pure breeding.

II. Racial Affinities. The Hawaiians have long been recognized as belonging to the Polynesian race, which is widely distributed in the Pacific area. Their nearest relatives are undoubtedly the peoples of the Marquesas and Samoan Islands. Their physical characteristics agree in general with those of the Samoans described by Sullivan. These differences are however to be noted: although of the same height as the Hawaiians, the Samoans exceed them somewhat in nearly all of the other physical dimensions recorded; the Samoan head appears to be both longer and broader than the Hawaiian, while in shape it is relatively narrower; the proportion of very short headed (index 85 and over) individuals is much higher among the Hawaiians; the Samoan face is larger and both absolutely and relatively broader than the Hawaiian; the nose of the Hawaiians, while smaller, is relatively broader than that of the Samoans; the frequency of straight hair is much higher among the Samoans than among the Hawaiians, although the general type of hair is similar. The differences between these groups are small and the resemblances many. The present data indicate that both belong to one large racial group — the Polynesian.

We have made no attempt to deduce the affinities or origins of this large group from the present data. Sullivan has tentatively classified the various traits of the Samoans as resembling the European, Negroid or Mongoloid races of man, and concludes that their physical traits resemble most closely those of Mongoloid peoples. In so far as the Hawaiians resemble the Samoans, and in so far as Sullivan's racial classification of traits is cogent, the same might be inferred from our data. Resemblances, however, as Sullivan rightly notes, do not always represent closeness of relationship, but may arise by independent variation, or may be produced by other than inherent causes. Another kind of data, in addition to careful description of individual and group characteristics, is needed for explanations of racial origins or affinities. Such data should consist of descriptions of the behavior of the characters of a race, such as the Polynesian, when crossed with several of its putative parent races such as the Mongoloid or the European. When truly heritable traits (and these are the only traits of evolutionary significance) can be observed in a number of generations, the amount of similarity or divergence between races may be inferred from the characters and variability of the hybrids. We have obtained a small amount of such evidence for hybrids between Hawaiians as one parent race and Chinese and Europeans as the other. Further discussion of the racial relationships of the Hawaiians and Polynesians may then be deferred until such evidence is presented.

PART II

DESCRIPTIONS OF OTHER RACES IN HAWAII AND OF DESCENDANTS FROM CROSSES OF HAWAIIANS WITH OTHER RACES

Chinese and Chinese-Hawaiians

From the standpoint of the student of race mixture, the most interesting cross which is taking place in Hawaii is that between the native Hawaiians and the Chinese. In numbers of hybrids produced, and in the general effect on the character of the Hawaiian population, this cross is not so important as that between Hawaiians and Europeans. The interest and scientific value of the Hawaiian-Chinese cross inheres in the first place in the relative purity of the races involved. The past history and present characteristics of both the Hawaiians and the Chinese indicate that both races have undergone a period of relatively pure breeding in the immediate past, during which time racial traits have become well defined and less variable than in more widespread and mobile races. The source of the Chinese participating in this mixture is distinctly local, since most of the Chinese in Hawaii have been imported as coolies from Canton Province and belong to the relatively conservative South Chinese type.

Secondly, this cross has taken place in recent times, the first Chinese to reach Hawaii in significant numbers having arrived in the decade 1870–80. The cross has been made practically always in one direction, i.e. Chinese male by Hawaiian female. In appearance, mentality, temperament and customs, the Chinese and Hawaiians present what appear to be well marked contrasts. There seems to be little or no social disapproval of marriages between these races; and both of the parent races and the hybrids live on what is practically a social parity. For these reasons the results of the cross should be simpler and offer fewer difficulties in interpretation than crosses involving Hawaiians and members of other races.

Description of the South Chinese

The description of the South Chinese which follows is based on our observations of twenty pure South Chinese living in and near

TABLE 24. MEANS AND VARIATION CONSTANTS OF ADULT SOUTH CHINESE MALES

	This series		Hagen's series			
	Mean [1]	Range	Mean	Range	S. D.	C. V.
Number of subjects	10[2]	10	56–64	56–64	56–64	56–64
Stature, cm.	165.2 ±1.1	155–171	161.37 ±0.46[4]	148–172	5.54 ±0.33	3.43 ±0.20
Sitting height, cm.	87.8 ±0.7	81–94	85.8[5]	....	....	....
Index of sitting height, %	53.1 ±0.3	51.2–56.5	53.2[3] ±0.13	....	....	....
Height of acromion, cm.	133.7 ±0.7	128–137	....	....	....	....
Arm length, cm.	74.3 ±0.6	68–78	72.4[3]	....	....	....
Index of arm length, %	45.0 ±0.2	42.9–46.4	45.0	....	....	....
Head length, mm.	188.7 ±1.6	174–200	182.31 ±0.55	166–194	6.52 ±0.39	3.58 ±0.21
Head breadth, mm.	149.3 ±1.3	140–158	149.48 ±0.49	137–164	5.85 ±0.35	3.91 ±0.23
Cephalic index, %	79.1 ±0.7	73–83	81.99 ±0.37	72–94	4.34 ±0.26	5.29 ±0.32
Bizygomatic diameter, mm.	139.7 ±1.2	131–149	140.66 ±0.41	129–150	4.56 ±0.29	3.24 ±0.21
Nasion-menton height, mm.	123.7 ±1.2	116–135	119.48 ±0.48	101–128	5.61 ±0.34	4.69 ±0.28
Facial index, %	88.5 ±1.0	79.9–97.0	84.94 ±0.43	73–92	4.83 ±0.31	5.70 ±0.36
Nasal height, mm.	52.3 ±0.7	49–56	....	....	....	....
Nasal breadth, mm.	41.3 ±0.4	38–45	....	....	....	....
Nasal index, %	79.0 ±1.3	72.7–91.1	79.0[3]	....	....	....

[1] Variation constants based on so small a sample have little value. We have therefore calculated the arithmetic average from the ungrouped measurements. The probable errors, being based on the Standard Deviation of only ten individuals, are approximations.

[2] One subject reporting age as 19 has been included in adult group.

[3] Hagen's mean.

[4] Weisbach gives mean height of 15,000 South Chinese as 162.2.

[5] Calculated.

Honolulu, and on Hagen's (1889) measurements of 64 adult male coolies from Canton, observed at Deli on the northeast coast of Sumatra. The Chinese of Hagen's series were born in China, while all except two of our series were born in Hawaii of pure Chinese parentage, the parents having in most cases been born in China. The original measurements of our series are given in Appendix Table II. Hagen's data are given in full in his memoir (21). We have calculated from both of these series of measurements the averages of the principal dimensions and proportions of the body, and these are given in Table 24 following. The observations on females are too few to be of use except in descriptions of non-mensurable traits.

In general the measurements of South Chinese males from Hawaii agree quite well with those obtained by Hagen in Sumatra. The Chinese measured by us were slightly taller, and longer headed and had slightly higher faces than those observed by Hagen, but the differences are small and generally insignificant. The two series together give as good an indication of the dimensions and proportions of the South Chinese as can be obtained at present.

The non-mensurable traits of our series of South Chinese are described in Table 25. The hair color is prevailingly black and uniformly straight and coarse; the eyes are brown, generally oblique and the Mongolian fold is present and marked in more than half of the subjects. The frequency of the fold is probably higher than that shown by our data, for in the first subjects observed no specific mention was made of this trait. Hagen noted the eye fold in 80 per cent of the South Chinese observed by him; and, while it varies in degree it is probably present in most of the South Chinese. The skin color is very similar to that of the Hawaiians. The root of the nose is generally depressed, the bridge straight, and the septum directed upwards. The forehead is of medium height and breadth and frequently receding. Prognathism is generally absent, only two subjects having been recorded as slightly prognathous.

Comparison of Hawaiians and Chinese

From the information provided above, a general comparison of the native Hawaiians and South Chinese can be made. The Hawaiians are taller and heavier than the Chinese; although the

Table 25. Descriptions of the Non-mensurable Traits of the South Chinese

Hair color	Black 19, Dark Brown 1			
Hair form	Straight 20			
Eye color	Brown 10, Black 2, Dark Brown 5, Light Brown 2			
Eye fold	Present 10			
	Absent [1] 8	♂	♀	
Skin color	Broca's Grade 23	5	3	
	Broca's Grade 24	3	–	
	Broca's Grade 47	3	–	
Nose form	Root, depressed 17			
	straight 3			
	Bridge, straight 14			
	concave 6			
	Septum, straight 5			
	up 15			
Lips	Thin 2			
	Medium 13			
	Thick 1			
Prognathism	Absent 14			
	Slight 2			
Forehead	Height	Breadth		Slope
	high 5	medium 13		straight 9
	medium 8	broad 3		receding 7
	low 3			
Brow ridges	Absent 8			
	Slight 5			
	Prominent 3			

[1] Five recorded as oblique eyelids; Two recorded as straight eyelids — presence or absence of fold not established by record.

proportions of the body are very similar in the two races. The Chinese appear to have slightly longer trunks; the difference in the sitting height index, although small, is statistically significant. The Hawaiians are predominantly brachycephalic, while the Chinese are frequently dolicho- or mesocephalic. The Chinese head is probably somewhat smaller than the Hawaiian; the principal difference being in absolute breadth of head,in which Hagen's measurements and our own agree. The faces of the Hawaiians and Chinese are quite similar in size and shape, the averages of the absolute dimensions being nearly identical. In nose shape the two races are slightly different, the Hawaiians having relatively and absolutely broader noses than the Chinese, although the difference is not large. The nose of the Chinese is typically depressed at the root, while in the Hawaiians it is more frequently of the European straight type. The septum of the nose is directed upward in the Chinese, but is generally straight or horizontal in the Hawaiians. The lips of the Hawaiians are somewhat thicker than those of the Chinese. One clearly marked difference is in the shape of the eye and in the presence or absence of the Mongolian fold. In the Hawaiians the eye is full, round and straight and the eye fold is absent; in the Chinese the eye is typically narrower, is set obliquely and the eye fold is generally present. The two races are also sharply distinguished by the form of the hair, which is uniformly straight and coarse in the Chinese, wavy and finer in the Hawaiians. The brow ridges which are generally present and frequently prominent in the Hawaiians are as a rule absent or slight in the Chinese. In the color of the hair, skin and eyes, in the incidence of prognathism and shape of the forehead, the two races are very similar. To the casual observer the Chinese and Hawaiians appear to be quite different and are readily differentiated. When the differences are measured and reduced to anthropometric terms, however, they are fewer than one would expect. They are chiefly concerned with general body size, a slightly different head shape, hair form, shape of the nose and the character of the eye. We may now turn to the behavior of these traits in inheritance, and formulate a description of the hybrids arising from crosses of Chinese and Hawaiians.

First Hybrid (F_1) Generation from Hawaiian × Chinese

Our data on this generation consist of descriptions of twenty-eight progeny of matings of pure Chinese males, with pure Hawaiian females. Of these hybrids four were mature males and ten were immature males ranging in age from fifteen to nineteen years. Of the fourteen females all except three were mature. In averaging the measurements of this generation only mature subjects have been used, with the exception that three males of age twenty have been considered as having attained adult growth in all traits except stature and its separate elements. Even with this addition, our description of the mensurable traits of the hybrids rests on only seven males and eleven females. The averages of males and females of this generation are contained in Table 26, while the descriptions of non-mensurable traits are summarized in Table 27.

Table 26. Averages of the Mensurable Characters of Adult F_1 Hybrids Between Chinese Males and Hawaiian Females

	Males		Females	
	Average	Range	Average	Range
Number of subjects	4–7	4–7	11	11
Stature, cm.	165.6	157–176	157.54±1.17	148–169
Sitting height, cm.	88.6	82–93	84.80±0.63	79–90
Sitting height index, %	53.5	52.1–55.1	53.83±0.32	52.3–57.8
Ht. of acromion, cm.	134.9	127–144	128.14±1.00	121–138
Arm length, cm.	73.0	67–77	68.79±0.71	64–76
Index of arm length, %	44.1	42.5–46.5	43.67±0.35	42.1–45.0
Head length, mm.	179.9±2.8	165–200	168.36±1.43	157–175
Head breadth, mm.	152.3±1.5	141–162	144.73±1.35	133–153
Cephalic index, %	84.5±0.8	77.5–93.3	85.96±0.67	79.6–89.5
Bizygomatic diam. mm.	138.7±1.8	129–146	131.18±1.30	124–144
Nasion-menton height mm.	119.4±2.3	109–138	109.27±1.26	99–117
Facial index, %	86.1±1.2	81.1–94.5	83.30±0.77	78.5–92.1
Nasal height, mm.	52.4±0.7	48–58	47.55±0.57	43–51
Nasal breadth, mm.	39.4±0.5	36–43	37.91±0.42	36–42
Nasal index, %	75.2±1.6	65.5–82.7	79.73±1.10	70.6–93.0

Mensurable Traits

An examination of Table 26 indicates immediately that only tentative conclusions can be reached regarding the average appearance of the hybrids in respect to most of the traits measured. The errors of the averages are so high, due to the smallness of the samples, that only very large differences from one of the parent races could be regarded as significant. And as we learned from the comparison of the pure Hawaiians and Chinese, such large differences, even between the parent races, are apparent only in stature and its segments. Concerning this dimension in the male hybrids, no statements can be made, for our average is based on but four individuals, two of which were as tall as the Hawaiian average, and two of which were shorter than the Chinese average. The height of the female hybrids is 157 cm. compared with 162 cm. for pure Hawaiian females. The height of South Chinese females is probably about 150 cm. (Hagen), although three Chinese females

Table 27. Descriptions of the Non-mensurable Traits of the F_1 Hybrids between Chinese Males and Hawaiian Females

Hair color	Black 26, Dark Brown 2		
Hair form	Straight 17, Slightly wavy 3, Wavy 6, Curly 1, Wiry 1		
Eye color	Dark Brown 11, Brown 15, Light Brown 1		
Eye fold	Present 11 (4 "slight")		
	Absent 9 [1]		
	No record 8	♂	♀
Skin color	Broca's Grade 23	4	–
	Broca's Grade 24	–	3
	Broca's Grade 40	1	–
	Broca's Grade 47	1	2
	von Luschan's Grades 8–15		
		♂	♀
Nose form	Root, depressed	9	12
	straight	5	2
	Bridge, straight	10	2
	concave	1	8
	convex	1	2
	no record	2	2
	Septum, straight	3	6
	up	11	8
Lips	Medium 8, thick 5		
Prognathism males	Absent 10, marked 1		
Brow ridges males	Absent 4, slight 3, marked 1		
Forehead	insufficient data		

[1] In these cases the angle of the eye was observed (5 oblique, 4 straight) but the presence or absence of the fold was not specifically noted. The absence of the fold in these subjects is probable but not established.

in our series averaged 153 cm. in height. The hybrids appear, therefore, to be intermediate between the parents in stature, a result which has usually been observed in crosses between animals and plants differing in size. Sitting height is likewise intermediate between the parental dimensions, although in both males and females, the relative length of trunk appears to be closer to the Chinese than to the Hawaiian average. The difference in the sitting height index between Hawaiian and hybrid females is, however, small (.70 ± .36 per cent) and probably not statistically significant. An examination of the range of variation in this proportion in the Hawaiians and hybrids shows that while the individual Hawaiian females varied from 50.5 to 56.9 in this index, the range of the hybrid females extends from 52.3 to 57.8. There were relatively fewer short-trunked individuals among the hybrids. It is doubtful whether or not this represents a tendency toward dominance of the longer relative trunk of the Chinese. It is more probably accounted for by the shorter stature of the hybrids; since, as Hrdlička has shown, shorter individuals have usually a somewhat higher index of sitting height. The slight differences found are probably due to the fundamental differences in general body size between the two parent races and the hybrids.

In acromic height and arm length the hybrids are likewise intermediate between the parent races, while the *relative* length of arm is somewhat less in the hybrid females than in the Hawaiian females. This difference is only twice as large as its error; and, since the parent races were very similar in this respect, it is probably due to sampling.

In the dimensions of the head and face the differences between the parent races were not marked, although the proportions of the head were somewhat different in that the head of the Chinese was relatively longer than the head of the Hawaiians. This racial difference in head shape is statistically significant.

The head length of the hybrids is somewhat less than that of either parent race. The difference in head length between the Hawaiian and hybrid females is 10.43±1.73 mm., while in the males the difference (2.5 mm.) although insignificant, is in the same direction.

In breadth of head the parent races did not differ greatly and the difference between the hybrids and Hawaiians is less than the difference in length of head. For the females, the difference in head breadth between the Hawaiians and hybrids is 5.53±1.51 mm.

The greatest difference noted is in head shape as measured by the cephalic index. The hybrids appear to have relatively shorter heads (a higher index) than either parent race. These differences are as follows:

Table 28. Difference in Cephalic Index

Groups compared	Males	Females	$\frac{\text{Difference}}{\text{E difference}}$ Males	$\frac{\text{Difference}}{\text{E difference}}$ Females
F_1 — Chinese	5.40±1.06		5.1	
F_1 — Hawaiian . . .	1.06± .84	1.80± .81	1.3	2.2

Lack of data precludes an exact comparison of F_1 with Chinese females, but we may assume the difference to be similar to that which exists between the males of the two groups. The most significant differences shown are between the hybrids and the Chinese. The hybrids have relatively shorter heads than the Chinese. The differences in head shape between the hybrids and Hawaiians are not statistically significant, although in both sexes the hybrids have relatively shorter heads.

The distribution of head form in the parent races and hybrids is compared in Table 29. The chief differences between the parent races are the relatively larger proportion of dolicho- and mesocephalic individuals among the Chinese and the greater frequency of brachycephaly among the Hawaiians. The hybrids plainly resemble the Hawaiians in this respect.

Table 29. Comparison of Head Shape in Hawaiians, Chinese and their Hybrids (Males and Females Combined)

	Number	Per cent dolicho-cephalic	Per cent meso-cephalic	Per cent brachy-cephalic
Hawaiian	108	2.1	9.8	88.0
Chinese	20	15.0	20.0	65.0
F_1	18	....	11.7	88.3

Considered in both of these ways the evidence indicates that the cross of the short headed Hawaiians with the slightly longer headed Chinese produces a distinctly brachycephalic average type. This alone might be interpreted, as similar results have been, by assuming dominance of shorter over longer headedness. But there is some possibility, which our evidence cannot make a certainty, that the hybrids are actually shorter headed than the shorter headed parent. This difference, if real, is probably due to the smaller bodily dimensions of the hybrids, which fail to attain the full height or size of the Hawaiian parents. There is some evidence (22) that all parts of the body are influenced by general growth or size factors, and it is known that within the same racial group the individuals of shorter stature have also shorter heads. Head length, as Boas (23 and 24) has shown, is more dependent than is head breadth on total stature. It may be possible to interpret such results as we have observed in terms of such general growth factors, without referring the differences to heritable factors affecting shape of the head. It is improbable that the reality or inheritance of such shape factors can be established from evidence such as ours on crosses involving differences in general body size.

In the size and shape of the face the Chinese and Hawaiians were found to be very similar. The hybrids appear to have somewhat smaller faces than the Hawaiians and in the female hybrids the face is relatively slightly lower and broader than in the Hawaiian females. The differences in this respect are not significant; and, while the cross may have altered somewhat the parental facial proportions, the results are not conclusive.

In the size and shape of the nose there were slight differences between the parents, the Hawaiian nose being somewhat larger and broader than the Chinese. The nose of the F_1 hybrids in both sexes resembles more closely the Chinese type both in size and shape. In our sample, the hybrids had relatively narrower noses than the Chinese, although in view of the variability of this character and the large errors of our averages this cannot be regarded as significant.

In general, few definite conclusions can be drawn from the comparison of the quantitative characters of Hawaiians, Chinese and hybrids. In size the hybrids appear to be intermediate, while in the proportions of the body they are nearer to the Chinese type. In head shape the resemblance is plainly toward the Hawaiian parent, while the face and nose resemble the Chinese. There is some indication that the hybrids may depart from the parental description even in traits in which the parents do not differ, and that the relations of parts may be altered by the cross of parents differing chiefly in general body size.

Non-Mensurable Traits

Several differences exist between the Hawaiians and Chinese in non-mensurable qualitative traits. The appearance of the hybrids in these respects is described in Table 27.

Hair Form. The greatest difference found was in hair form, the Hawaiians having wavy or curly (rarely straight) hair of the European type, the Chinese without exception having coarse straight hair of the Mongoloid type. The significant feature of the F_1 generation is that it is not uniform in respect to hair form. Seventeen or sixty per cent of the hybrids had straight hair; while of the remaining eleven individuals, ten had wavy or curly hair of the Hawaiian type while one had wiry hair. The genetic relationship between the straight Mongoloid type of hair and the wavy European type has not been established, although the evidence of Bean (25) and of other observers makes it appear probable that the Mongoloid type behaves as a dominant trait in inheritance. Our evidence partially corroborates this assumption in that the majority of the hybrids had straight hair of the Mongoloid type. Whether the lack of uniformity of the first generation in respect to hair form is due to variable or incomplete dominance of Mongoloid straight over wavy and curly hair, or to misinformation concerning the pedigrees of the wavy and curly haired F_1 subjects, cannot be established from the present evidence. The single wiry haired F_1 subject was a female, whose other physical characteristics did not depart widely from the means of the F_1 generation. This exceptional hair form may have been due to artificial deformation or to otherwise unexpressed negro blood in the ancestry.

Epicanthic Fold. The Hawaiians and Chinese were found to differ sharply in the presence or absence of the fold of the upper eyelid, known as the Mongolian or epicanthic fold. This fold was observed to be present in eleven of the F_1 hybrids. Of the remaining seventeen, eight were not observed for this trait, while in nine the entries on the schedule indicate that the eye was examined but do not reveal whether the fold was present or absent. It was probably absent or slight, and was hence not recorded. The presence of the fold is certainly established in a majority of the F_1 hybrids, and it is therefore inherited as a dominant trait.

Nose Form. In nose form the hybrids apparently resemble the Chinese more than the Hawaiians. The root is more frequently depressed, as in the Chinese, than straight, as in the Hawaiians; although both types of root are found, even among pure Hawaiians. The bridge of the nose in typically straight in the male hybrids, and concave in females as in both parent races. The septum of the hybrids is generally directed upwards, which is the typical description of the Chinese nose, whereas in Hawaiians the septum is usually straight or horizontal.

The lips of the hybrids are probably intermediate in thickness between the Hawaiian and Chinese types, although both parent races have lips which vary about a medium thickness. In other traits the differences between parents and hybrids are unimportant.

General Character of the First Hybrid Generation

1. Homogeneity. The results of crossing animals and plants differing in quantitative characters have shown that in general the offspring of a cross between two pure (inbred) types are no more variable in respect to a given character than the more variable of the parent types. The homogeneity of the F_1 generation may under certain conditions be used as an indication of the relative purity of the parental types. In the present case, paucity of numbers precludes an exact comparison of the variability of F_1 and parental types, but the range and dispersion measures of the mensurable traits of the first generation compare favorably with those of the pure Chinese. In a few traits (e.g. hair form) the F_1 generation is more variable than should be expected if the race containing the assumed dominant trait (Chinese) were entirely pure. This, and a certain part of the variability of other traits in the first generation, may perhaps be due to some misinformation concerning pedigrees and the inclusion in the F_1 generation of a few subjects of later generations in which segregation is taking place, resulting in increased variability.

2. Resemblances to Parents. In general the F_1 generation is intermediate in character between the parent races. Such a result is usual in crosses between types differing in quantitative traits such as size. Wherever the hybrids resemble one parent more than the other, the resemblance more often appears to be toward the Chinese type, as in relative trunk length, hair form, and facial features (eye, nose, etc.). In one trait, i.e. head form, the hybrids while nearer to the Hawaiian type depart to some extent from both parental averages. This may be due to a combination of factors from both parents, producing a new or a phylogenetically older character, a result not without parallel in experimental animal breeding (recombinations, reversions, etc.).

The Backcross Generations

Critical data on the inheritance of the traits which differentiate races can only be obtained when some description of the behavior of these traits in the germ cells of the hybrids is available. In the present case, we have very little data on the results of matings between two F_1 hybrids. We have more data on the results of matings between F_1 hybrids and one of the pure parent races. The most frequent mating of this kind is between F_1 hybrids and pure Hawaiians. The raw data on the progeny of such matings are given in Appendix Table III. Summaries of the averages of mensurable traits are given in Table 30, and of descriptive traits in Table 31.

Progeny from Matings of F_1 with Hawaiians

The total number of subjects of this generation observed was twenty-eight. Of these only nine were mature, three males and six females. The averages of the mensurable traits are, therefore, of

Table 30. Averages of the Mensurable Characters of the Progeny of Matings of F_1 Hybrids with Pure Hawaiians (Backcross Generation)

	Males		Females	
	Average	Range	Average	Range
Number of subjects	3	3	6	6
Stature, cm.	167.6	163–173	158.18 ± 1.43	153–167
Sitting height, cm.	85.9	85.3–86.6	84.77 ± 0.58	83.0–88.9
Sitting height index, %	51.2	49.3–53.1	53.60 ± 0.19	52.5–54.6
Height of acromion, cm.	136.5	133–141	128.33 ± 1.31	122–137
Arm length, cm.	76.0	74.2–77.8	70.18 ± 1.05	67.0–78.1
Index of arm length, %	45.3	45.0–45.6	44.37 ± 0.29	43.5–46.6
Head length, mm.	186.3	178–195	171.67 ± 2.21	159–183
Head breadth, mm.	152.3	147–163	143.33 ± 1.61	135–151
Cephalic index, %	81.7	75.3–91.6	83.49 ± 0.93	76.5–86.3
Bizygomatic diam., mm.	147.7	142–154	133.83 ± 1.60	126–143
Nasion-menton height, mm.	122.0	116–126	109.50 ± 1.15	103–116
Facial index, %	82.6	75.3–87.3	81.82 ± 1.24	76.2–89.2
Nasal height, mm.	53.0	52–55	48.00 ± 0.94	42–52
Nasal breadth, mm.	44.0	43–46	40.00 ± 0.35	38–42
Nasal index, %	83.0	78.2–88.4	83.63 ± 1.17	78.4–90.5

Table 31. Descriptions of the Non-mensurable Traits of the Progeny of Matings of F_1 Hybrids with Pure Hawaiians

Hair color	Black 24, Dark Brown 3, Red Brown 1		
Hair form	Straight 9, Wavy 11, Curly 7, Kinky 1		
Eye color	Brown 12, Dark brown 14, Light Brown 2		
Eye fold	Present 14 (4 "slight")		
	Absent 12 (presence or absence of fold not established: 10 straight, 2 oblique)		
	No record 2		
		♂	♀
Skin color	Broca's Grade 23	1	6
	Broca's Grade 24	–	3
	Broca's Grade 29	1	–
	Broca's Grade 40	1	3
	Broca's Grade 46	1	–
	Broca's Grade 47	–	1
		♂	♀
Nose form	Root, depressed	9	8
	straight	3	6
	Bridge, straight	6	6
	concave	2	8
	convex	1	–
	no record	3	–
	Septum, straight	3	4
	up	9	9
	no record	–	1
Lips	Thick 19, medium 4		
Prognathism	Absent 11, slight 3		
Brow ridges	Absent 9, slight 1		

little value. As far as the meager data go they indicate a greater resemblance between this generation and the pure Hawaiians than between the F_1 and the Hawaiians, although in general size these subjects, who are three-fourths Hawaiian, are still intermediate between the Chinese and Hawaiians. The head form of the subjects in this generation is likewise intermediate between the head form of the parent races, indicating that the increase in the cephalic index noted in F_1 was probably due to combinations of factors which take place principally in the F_1 generation. Nose form in this generation also shows a return to the broader Hawaiian type.

The description of the non-mensurable traits of this generation, although based on twenty-eight subjects, provides but little data on the inheritance of separate traits. The principal non-mensurable differences between the parent races are in hair form and the presence or absence of the eye fold.

Hair form. Of the twenty-eight subjects, nine were recorded as having straight hair; while eighteen had wavy or curly hair. The hair form of one subject was described as " almost kinky." Both parents of this subject (No. 11) were observed together with seven sibs. There was no evidence of kinky hair or other negroid traits in any of these relatives, and it is probable that the aberrant hair form is in this case an extreme variant of the curly type. The significant points to examine in these data are (1) whether there is evidence of segregation of the straight and wavy-curly types of hair, (2) the numerical relations of these types.

Unfortunately it is not possible to state whether the straight hair encountered in these hybrids was of the coarse Mongoloid type or of the finer straight type which is occasionally found in pure Hawaiians. Photographs of some of the straight haired subjects give some evidence that the Mongoloid type occurs even in subjects which are three quarters Hawaiian. Better evidence on the segregation of these hair types is found in one family of which both parents and eight children were observed. The mother in this case was a straight haired F_1; the father was a curly-haired Hawaiian. Of the eight children, five had curly (one " almost kinky ") hair, while three had straight hair. The absence of the intermediate hair form — wavy — in this family strengthens the supposition that these differences in hair form depend on Mendelian factors which segregate cleanly.

The ratio of wavy to straight haired subjects in this generation has little significance, since in most cases the hair form of the individual F_1 parents is not known; and we have already shown that the F_1 generation was not uniform in hair type. It is probable, however, that the frequency of straight hair is higher in the backcross generation than in the pure Hawaiians, and this may be assumed to be due to dominant factors for straight hair introduced by the Chinese grandparents. In the single family observed, the ratio of curly to straight haired children is close to that expected on the assumption that one dominant factor differentiates curly from straight.

Eye fold. Our records show that the eye fold appears in half of the subjects of the backcross generation. The occurrence of this typically Chinese trait in individuals which have only one-fourth Chinese blood is very good evidence that the epicanthic fold depends on dominant factors, and confirms a similar conclusion drawn from the data on the F_1 generation. This trait apparently, in some cases, segregates from the hybrid in its original form, while in a few cases it is recorded as "slight" in the backcross subjects, so that its expression may be altered by other factors. Evidence that the alternative trait (absence of the fold) segregates as a recessive is found in the family of eight children (Nos. 6–15) descended from the mating of an F_1 female by pure Hawaiian male. In this case both parents lacked the fold and it does not appear in any of the children.

The numerical ratio in which the eye fold segregates appears on casual inspection to be the ratio expected if it depended on a single dominant factor. Thus it appeared in fourteen of the backcross subjects and was not noted in fourteen (absence of notation probably indicates absence of the trait, since it is a prominent feature when present). This coincides exactly with the ratio expected when individuals heterozygous in a single factor are crossed to the recessive form. We know, however, that the data are not sufficient to establish such a conclusion, since (1) the character is not expressed in all pure Chinese, (2) the F_1 generation is not uniform, (3) the number of observations of backcross individuals is small. We are content to establish the dominance and segregation of this trait and to point to it as offering a favorable opportunity for making a factorial analysis of a typically "racial" trait.

The other descriptive traits are too variable, the differences between the parents too poorly defined and the data too meager to justify conclusions.

Other Hawaiian-Chinese Mixtures

The remaining subjects observed by us fall into groups which are too small for quantitative treatment. The F_2 generation consists in our data of but six subjects, all females, of which only three are mature. The measurements and observations of these subjects are given in Appendix Table III. Inspection of these data and comparison with the observations of the pure races and other hybrids indicate the presence of Chinese traits — presence of Mongolian fold, straight hair, etc. — in combination with some traits more characteristic of the Hawaiians — tall stature (subject No. 160), brachycephaly (No. 250). No satisfactory estimate of the variability or recombinations of quantitative traits can be made from the few descriptions at hand.

The generation arising from the backcross of F_1 by Chinese consists of two males and three females including one mature individual. On account of the paucity of numbers and immaturity of the subjects they cannot be compared with the parent races in respect to quantitative traits. In three of them the Mongolian fold was present, while in one it was absent and in one the trait was not recorded. In spite of the fact that each subject had one pure Chinese parent, two of them were found not to have the straight coarse hair which is typical of the Chinese and which we found was probably inherited as a dominant. The curly-haired subjects in this generation, like those in the first hybrid generation, may have risen from a cross other than that specified on their schedules, or their presence may indicate incomplete dominance of straight over curly hair. Except for dominant Hawaiian traits and a somewhat greater variability, this generation should resemble the first hybrid generation, and such in general is the case.

The measurements of eight other subjects recorded on the schedules as "part Chinese" are given in Appendix Table III under the heading "Other Hawaiian-Chinese Mixtures." These are nearly all immature subjects whose schedules indicate the presence of both Hawaiian and Chinese ancestors in their pedigrees. The degree of mixture is unknown. They form a rather variable group in which both Chinese and Hawaiian traits appear. The evidences of Chinese admixture are unmistakable since the Mongolian eye-fold appears in every subject of the group. In two cases this is combined with wavy hair indicating that these subjects are probably the offspring of F_1 parents or parents of later generations. Several are taller than pure Chinese, while the distribution of head shapes is similar to that found among Hawaiians.

Discussion. The brief descriptions of the parent races involved in the crosses described, and the appearance of the hybrids produced, make it evident that the chief differences which distinguish the Hawaiians and Chinese are due to heritable factors which unite temporarily and later separate and reappear in various combinations. Dominance is in general absent, as has been found generally to be the case with quantitative traits. Where one racial trait appears to exclude or nearly to exclude its alternative, the more dominant trait appears to have been derived from the Chinese parent. The evidences of Chinese blood in the hybrids are throughout more easily and certainly distinguishable than the Hawaiian traits. Segregation of several distinctly racial traits unquestionably occurs as well as a degree of independent recombination of separate traits, so that while many Hawaiian-Chinese hybrids appear to represent " blends " of the parental race traits, many are more accurately described as "mosaics," showing traits of both races in almost typical form.

In contrast to the few differences which were noted between these races, are the many resemblances. Many such resemblances may be merely fortuitous and due to the similar expression of different hereditary factors. But if such were the case here we should expect to find in the hybrids many new or reversionary traits. Except in the case of head shape, such traits if present in the hybrids were not prominent enough to be noted and we may infer a fairly close genetic affinity between the Hawaiians and Chinese.

Both races were very variable in most of their characters, although not more so than the average " pure " race. The hybrids also were quite variable, and there is no question that the variability of the generations subsequent to the F_1 has been increased by the cross. However, this variability is thought not to exceed that of the parent types by an amount sufficient to indicate that the parent races differ in an extremely large number of genetic factors. It is easy to overemphasize the differences in physical features, because of the relative prominence of one or a few traits. For example, the Mongolian fold and the shape of the eye give a Mongolian cast to the face of many individuals of quite diverse origins. Yet the really important distinction to be made between races is the number, rather than the magnitude of the expression, of the inherited factors in which they differ. And we have seen that such a prominent trait as the eye-fold probably depends on relatively few hereditary differences; while it is evident that a slight difference in some quantitative trait such as stature or head shape may involve a large number of factor differences.

Our data are probably not adequate to establish the presence or absence of heterosis or hybrid vigor, a phenomenon which frequently accompanies the crossing of distinct races. As far as our data go, however, no marked increase in the size of any physical trait is in evidence. The vigor resulting from crossing varieties which differ in many factors, however, is often expressed in physiological traits such as fertility, rate of growth and others, for which we have no data in the present instance.

On the other hand, we encountered no evidence of disturbance of the normal course of development as a result of the cross. From the evidence on physical features we may say that the act of crossing has neither increased nor decreased the vigor, average size or fitness of the resulting hybrids. The impression gained by the observer was that the hybrids arising from the cross of Hawaiians and the Chinese were normal persons, frequently combining the more valuable personal characteristics of both parent types. Persons of this descent are apparently not handicapped, either physically or mentally, in comparison with either parent type.

WHITE RACES AND WHITE-HAWAIIAN HYBRIDS

The white races have been represented in the population of Hawaii, in greater or less numbers, for about a century and a half. It is probable that race mixture involving Europeans and Hawaiians has been taking place to some extent during all this time. European immigration into Hawaii did not attain any considerable proportions, however, until about fifty years ago, when deliberate attempts to colonize the islands with European laborers were begun. This movement began with the transportation of Portuguese laborers from Madeira and the Cape Verde Islands in 1878, followed by a considerable immigration from these Portuguese possessions, and later by the transportation of laborers from Porto Rico, beginning in 1900. At the same time a steady but numerically less important immigration of North Europeans and Americans began. It is thus only from the last quarter of the nineteenth century that race mixture between Europeans and Hawaiians has taken place in any important degree.

In 1919, it was estimated that Europeans constituted about 23 per cent of the population of the islands. This fraction consisted of about 12 per cent of North European peoples, British, Scandinavians, Germans, Americans etc., over 9 per cent of Portuguese, chiefly from the Cape Verde Islands, and frequently showing evidence of negro admixture, and about 2 per cent of Porto Ricans, largely Spanish in origin. However, the numerical proportion of these various kinds of Europeans does not represent the relative contribution of the white races to the racial mixtures which are taking place in Hawaii, for it has been found that the frequency of matings between Europeans and Hawaiians is quite out of proportion to the relative size of the European population. Thus, of all hybrids between Hawaiians and members of other races which were observed for the purposes of this study, 57 per cent involved a member of one of the European races. From McCaughey's (1) study of the frequency of mixed marriages in Hawaii and from Hoffman's (3) analysis of the vital statistics of Honolulu, it may be concluded that at least half of the racial crosses in which the Hawaiians have participated, have been with members of the white races. This means that numerically the Hawaiian-white mixture is at present the most important one in Hawaii.

As biological material, the Hawaiian-European mixture, although of great social importance, is not as suitable for study as the Hawaiian-Chinese cross. The European parent types are not homogeneous, but extremely variable, including, as is shown below, such mixed or racially composite types as "Americans" and north and south Europeans, which in their progress toward Hawaii have frequently mingled their blood with that of American Indian, negro and other peoples. A second disadvantage for the student of race mixture is that the differences between Europeans and Hawaiians are not so clearly marked as those which distinguish Chinese and Hawaiians, and it is therefore more difficult to follow these differences in inheritance. A somewhat greater amount of data are available for this cross and some fairly constant differences have appeared, so that while general conclusions cannot be drawn, the description of the Hawaiian-European hybrids is not without interest.

European Parent Types

It is obviously impossible to give an exact description of the characters of the white parent type such as we attempted for the Chinese parent type. Two quite different European types are represented, each of which is itself heterogeneous. The North European groups consist chiefly of the racially composite British and white Americans with many Scandinavians, and Germans. The South European groups are chiefly Portuguese or Spanish in origin, but had been brought to Hawaii from colonized islands in which considerable mixture with negro and native types had already taken place. In our analysis we have been chiefly concerned with the hybrids from the North European groups, and have dealt separately in all cases with the descendants of North and of South European types. It is impractical, from the data at hand, to make any further subdivisions of the white parent stocks. It must therefore be realized at the outset that the white parents of the Hawaiian hybrids are a complex racial group, even when restricted to a North European origin.

We shall then follow the rule of describing each Hawaiian-white hybrid group (F_1, F_2 and backcrosses), and of comparing the characters found with those of the pure Hawaiians as described in Part I, and with the probable condition of each trait in the average North European, a procedure which obviously can lead to only approximate statements. For comparative European material we have drawn chiefly from the measurements of Davenport (26) on soldiers of known race in the U. S. Army 1917–19, those of Goring (27) on English prisoners, and the racial means as collated by Martin (13). These references have been used in forming an estimate of an average North European type. The best comparative data from a mixed Polynesian-white group are those of Shapiro (28) on the inhabitants of Norfolk Island, which are known to be the descendants, through inbreeding, of hybrids between Tahitians and English.

The number of subjects of mixed Hawaiian and white parentage is larger than in the case of the Chinese-Hawaiians. We have observations on a total of 147 hybrids involving Hawaiian and white European ancestry, distributed as follows: $F_1 - 36$; $F_2 - 30$; backcrosses 60; other mixtures 21. In about 25 of these, the white ascendant was Portuguese or Spanish, in the remaining cases the white ascendant was from North Europe or America.

In comparing these hybrids with the parent types we have classified all subjects into adult and immature groups, and treated the sexes separately as in Part I, while, in addition, the descendants of North Europeans have been separated from the descendants of South Europeans. This has resulted in many small distributions.

The means and variation constants of these small series have been calculated from the ungrouped frequencies. The constants for indices or proportions have been calculated from their arrays, since it is impossible to use a method involving a knowledge of correlation for such small series. This produces a slightly higher average value than the method used in Part I (97).

Comparison of Hawaiians and Whites

At the outset we are faced with the question: In what specific traits do the Hawaiians differ from the races of Europe? In gross appearance the Hawaiian is readily distinguishable from the average European. The darker skin, hair and eyes of the Hawaiian, his broader nose, slightly thicker lips, large square face, and brachycephalic head distinguish him at once from the blonde Nordic type of northern Europe, while his greater stature, his head-form, bodily dimensions, corpulence, and heavy face set him apart from those Southern European types from which he differs less markedly in pigmentation.

When one attempts to specify the chief differences between the Hawaiian and the European, one finds that the most noticeable and constant differences, apart from skin color, relate to the general build or fullness of the body, the shape and size of the face as a whole and of the nose in particular. The Hawaiians are stouter than the Europeans, that is, they carry more flesh in proportion to their height. The face of the Hawaiian is square, fleshy and massive, while the typical North European face is oval and slighter. A comparison of the actual facial measurements of the two races shows that the Hawaiians only slightly exceed such a representative European type as the English in facial breadth and height. The measurements available describe only the shape of the upper part of the face whereas it is the greater size of the lower face and the greater amount of flesh which distinguish the Hawaiians. The difference in nose form is of a similar sort, although less constant, the Hawaiians having in general larger and broader noses than the Europeans. The nose of the North European has a higher, narrower root than is found among the Hawaiians.

In head form, the greatest difference is in absolute length of head, in which the North Europeans greatly exceed the Hawaiians. Head breadth is not greatly different in the two races, the Hawaiians having only slightly broader heads. In average head shape the difference is well marked, the North European having generally a dolicho- or mesocephalic head, while the Hawaiians are predominantly brachycephalic. Throughout, the chief differences between Hawaiians and Europeans appear to be those of degree rather than of kind, and are in general less marked than those which differentiate Hawaiians and Chinese.

First Hybrid (F_1) Generation from Hawaiian × White

We have observations of 36 subjects whose ancestry is given as: mother Hawaiian, father white (German, American etc.). In all except one case the non-Hawaiian parent was the father. This agrees with other data from marriage statistics which show that most persons of mixed blood in Hawaii originate in matings of Hawaiian women with men of other races. Of these F_1 subjects, 21 are adults (14 males and 7 females). Again subdividing on the basis of racial origin of the white parent, we find 10 adult male and 6 adult female offspring of North European × Hawaiian. The description of the mensurable physical traits of the hybrids is based on the average of the measurements taken on these 16 subjects. The hybrids resulting from crosses of Hawaiians with South Europeans (Portuguese and Spanish) are fewer in number, comprising only 4 adult males and 4 immature subjects. Descriptions of the non-mensurable traits rest on observations of 26 Hawaiian-North European hybrids of all ages and of 8 Hawaiian-South European hybrids.

The most reliable information on the characters of the hybrids is to be obtained from the adult males of the Hawaiian-North European crosses. The nativities of the fathers of this group are American 3, German 2, Scotch 3, Canadian 1, unspecified North European 1. The averages and variation constants of the chief measurements of these subjects are given in Table 32. These averages are to be compared with the corresponding averages for adult male Hawaiians (Table 22, p. 125), and with a general average for the trait in North European peoples. The latter can be obtained only by estimation and has relatively little value.

Body Size. In stature it is probable that the North European parents, if they are a random sample of the North European type, average slightly taller (about 172 cm.) than the pure Hawaiians

(171.3 cm.). The North European hybrids average 173.5 cm., and, although the probable error of the average is so large that it cannot be established as significantly different from either the Hawaiian or European average, it is probable that the hybrids are slightly taller than the Hawaiians. The Tahitian-white hybrids of Norfolk Island also appear to be taller than the Polynesian parent type. These hybrids have the high average stature of 174 cm., whereas the English parents probably averaged not more than 172 cm. and the Tahitian parents about 171. Other length dimensions of the body (acromial height, sitting height, arm length), are likewise slightly greater in the hybrids than in the Hawaiians and are probably intermediate in size between the parent types. In the proportions of the body there is very little difference between the Hawaiians, North Europeans and hybrids. In the index of sitting height, for example, the probable European value is about 52.4 per cent, Hawaiian 52.6, hybrid 52.3.

There exists, however, one unquestionable difference in body build between the European and Hawaiian peoples. This is the difference in body weight, and especially in relative corpulence as measured by the ratio of height to weight. The Hawaiians are heavy (average weight 170 pounds for males) and have a very high height-weight index, i. e. $I = \left[\frac{\text{wt.} \times 100}{\text{height}^3}\right] = 1.53$. The average weight of North Europeans is much less, probably about 150 pounds (the average weight of white drafted soldiers in the U. S. Army 1917 was 144 pounds) while they are less corpulent, with an average height-weight index of about 1.30 – 1.35. The hybrids of our sample exceed both parent races both in weight (male average 194 pounds) and in the height-weight index (1.68). The Norfolk Island hybrids are also characterized by a relatively great weight (169 pounds). The weights of both the Hawaiian and Norfolk subjects include clothes and are probably accurate only to within 5 or 10 pounds, yet both sets of data indicate large size as a characteristic of the Polynesian-white mixtures. Before concluding that such corpulence as characterizes the Hawaiians is a heritable, dominant trait in racial crosses we must consider (1) that our sample of hybrids is very small and may not be representative of the average F_1 type; (2) that body build is undoubtedly conditioned in part by environmental factors such as nutrition, occupation, and the relative ease or difficulty of getting a living, and that the corpulence of both the hybrids and the Hawaiians may be due to the action of a common environment rather than to heredity; (3) that the large size of the hybrids, since they exceed even the heavy Hawaiians, may be due to hybrid vigor or heterosis. These possibilities may be discussed more profitably after the evidence from more hybrids of later generations is presented.

Head. One of the chief differences between the Hawaiians and North Europeans is in absolute and relative length of the head. The Hawaiians have characteristically short heads (average 182 mm.) while the head of the average North European is longer (190 mm. or more; 192 for Goring's English prisoners and 198 for von Luschan's English scientists). In breadth there is little difference between the Hawaiians (152 mm.) and the North Europeans (about 150 mm.). These dimensions produce a typically brachycephalic head in the Hawaiians, while the North Europeans are predominantly dolichocephalic or mesocephalic. The absolute size of the hybrid head is greater in both dimensions than that of the Hawaiians. The hybrids, like the Hawaiians, are predominantly brachycephalic, with a mean index of about 83, which is the same as the Hawaiian index. This condition holds not only for the adult male hybrids now under discussion but for all of the F_1 hybrids. In a total of 36 hybrids only 1 case of dolichocephaly was found (index 75), 1 subject was mesocephalic (index 79) while the remaining 34 were brachycephalic with indices resembling those of the Hawaiians. It is evident that the F_1 hybrids resemble the more brachycephalic of the parent races. Our Hawaiian-white hybrids differ in this respect from the Norfolk hybrids, since the latter have on the average absolutely long heads (average 195.6 mm.) while their heads are no broader than those of our F_1 individuals (Norfolk breadth 155.5 mm.). The resulting head shape of the Norfolk Islanders is mesocephalic (index 79.5) and the series includes many with dolichocephalic heads. The average head dimensions and the distribution of head shape among the Norfolk Islanders have undoubtedly been affected by the reappearance through segregation of the recessive European type (long head, low index), and are thence not strictly comparable with our F_1 type.

In the present case the inheritance of head shape is probably uncomplicated by differences in general body size, since the Hawaii-

TABLE 32. MEANS AND VARIATION CONSTANTS FOR THE F_1 HYBRIDS BETWEEN HAWAIIAN FEMALES AND NORTH EUROPEAN MALES

	10 Adult males				10 Adult females	
	Mean	Range	S. D.	C. V.	Mean	Range
Weight lbs.	193.9*	132 –260	......	....	....	......
Stature cm.	173.48 ± 1.22	162 –181	5.72 ± .86	3.30	162.6	156 –167
Acromic height cm.	142.61 ± 1.05	133 –150	4.93 ± .74	3.46	134.0	127 –139
Sitting height cm.	90.69 ± .82	83 – 94	3.85 ± .58	4.24	87.5	86 – 89
Index of sitting height, %	52.28 ± .22	50.5– 54.2	1.04 ± .16	1.99	53.7	51.7– 55.3
Arm length cm.	78.76 ± .67	74 – 85	3.14 ± .47	3.99	70.1	65 –74
Index of arm length, %	45.39 ± .20	43.9–46.6	.95 ± .14	2.09	43.1	41.9– 44.1
Head length, mm.	188.80 ± 1.87	177 –206	8.78 ± 1.32	4.65	173.6	164 –189
Head breadth, mm.	156.60 ± 1.89	138 –167	8.86 ± 1.34	5.66	147.4	140 –156
Cephalic index, %	83.01 ± .95	75.0– 90.7	4.46 ± .67	5.37	85.0	80.9– 87.4
Bizygomatic diameter, mm.	145.40 ± 2.21	127 –165	10.35 ± 1.56	7.12	135.4	127 –152
Nasipn-menton height, mm.	125.10 ± 1.36	112 –137	6.39 ± .96	5.11	116.6	110 –126
Facial index, %	86.29 ± 1.04	78.9– 94.9	4.89 ± .74	5.67	86.3	80.3– 96.9
Nasal height, mm.	53.80 ± .93	46 – 61	4.38 ± .66	8.14	52.4	46 – 56
Nasal breadth, mm.	43.10 ± .52	40 – 49	2.43 ± .37	5.64	35.6	33 – 41
Nasal index, %	80.75 ± 1.95	70.5–98.0	9.14 ± 1.38	11.32	68.3	62.5– 75.9

[1] Average of nine subjects.

ans, the North Europeans and their hybrids are similar in stature. This cross is quite different from the Hawaiian-Chinese cross, in which the parent races differed in general size as well as in the dimensions of the head. That the present cross between brachycephalic and dolicho- or meso-cephalic types of equal height produces almost exclusively brachycephalic offspring, is good evidence that the factors which produce or influence brachycephaly are dominant in inheritance. This result has been observed so frequently that the dominance of brachycephaly may be regarded as established.

The action of the factors affecting head shape is, however, obscure. In the cross of Hawaiians and Chinese, brachycephaly in F_1 appeared to be due to the absolutely shorter heads of the hybrids. In the present case this is not so, since the length of the F_1 head is significantly longer (by 6.4 ± 2.0 mm.) than the Hawaiian head. It is also broader (by 4.6 ± 1.9 mm.) than the Hawaiian head. Here both dimensions of the Hawaiian head have been equally affected by the cross with North Europeans, and one cannot say that the dominance of brachycephaly is due chiefly to the dominance of either one of the dimensions.

Face. In facial dimensions the chief difference between the Hawaiians and Europeans is in the breadth of the face. The bizygomatic diameter of the face is about 135–7 in North Europeans, (137.5 mm.) for the English males measured by Goring (27, 66), while the Hawaiians of our sample averaged about 140 mm. However, Sullivan (11a) found a facial width somewhat higher than this (144.5 mm.) in his large sample of pure Hawaiians, and other Polynesian groups have in general rather wider faces than we have found in the Hawaiians. In face width the F_1 hybrids undoubtedly resemble the Polynesian rather than the European type. This is evident from the average bizygomatic diameter of F_1 (145.4 mm.), and it is especially noticeable on the living subject and in photographs. The Norfolk hybrids, on the other hand, have a bizygomatic diameter (140.9 mm.) which resembles the European rather than the Polynesian average. The length of the face (nasion-menton height) is similar in Europeans and Hawaiians. In Goring's English males, for example, the measurement is about 124 mm.; in the Hawaiian males of our sample it is about 123 mm.; while in Sullivan's sample of Hawaiian males it is a little greater than 125 mm. In the hybrid males, facial length is 125 mm., not significantly different from either parent race. The same face height is characteristic of the Norfolk Islanders (125.3 mm.). The index describing the shape of the face is probably slightly different in Hawaiians and Europeans, the faces of the latter being somewhat more elongated. In Goring's English males the length of the face is about 90 per cent of the breadth; in our Hawaiians this index is about 88, while in Sullivan's series it is about 87. In the F_1 hybrids, the facial index is about 86. While the hybrid index is undoubtedly nearer to that of the Hawaiians, the differences are small, and due chiefly to variation in the absolute breadth of the face, which appears to be the more important distinguishing facial measurement. The facial index of the Norfolk Island hybrids (88.9) is more like that of the English than that of the Polynesian parent type, chiefly due to the narrower bizygomatic diameter. Since we have already found that brachycephaly appears to be dominant in crosses, it is not surprising that the broader Hawaiian face should also seem to be dominant, for facial and cephalic shapes are of course positively correlated and may be expected to depend in part on the same or similar factors. In the shape of the lower face, and in amount of flesh, the F_1 hybrids appear also to bear closer resemblance to the Hawaiian than to the European parent type.

Nose. In the absolute measurements and shape index of the nose there is a well marked difference between Hawaiians and the average European, although nasal dimensions are extremely variable in both parental and hybrid types. Using only data from male subjects for comparison, the height measurements are found to be similar in Hawaiians (53.6 mm.), English (52–53 mm. Goring), and hybrids (53.8 mm.). The breadth of the lower part of the nostrils is, however, plainly different in Hawaiians (44.2 mm.) and English (35–36 mm.), while the hybrids closely resemble the Hawaiians. The nasal index of the hybrids is nearly the same (80.8) as that of the Hawaiians (82.9), and unquestionably higher than that of the average North European (65–70). Here again the size and especially the breadth of the Hawaiian type appears to be dominant. In this respect the Norfolk hybrids again show greater similarity to the English type since in mean nasal height (55.3 mm.), breadth (37.6 mm.) and index (68), they approach very closely to the European measurements and depart markedly both from our Hawaiians and F_1 hybrids. Comparison of the descriptions of the various parts of the nose indicates plainly the partial dominance of the higher nasal root of the European type as shown below.

TABLE 33. FREQUENCY OF VARIOUS TYPES OF NOSE FORM IN PER CENT

	Root			Bridge			Septum		
	High	Straight	De-pressed	Straight	Con-cave	Con-vex	Straight	Down	Up
73 Haw. Males	0	63	37	60	19	21	53	3	42
12 F_1 Males	42	50	2	66	17	17	83	..	17

The only other significant difference shown by this comparison is the lower frequency among the hybrids of the upward direction of the nasal septum which occurs in nearly half of the Hawaiians but in less than a fifth of the hybrids. This trait, which is associated with the broader nose of the Hawaiians, has been nearly extinguished by the cross with European types. The nose of the hybrids as a whole then represents a new type different in some respects from that of either parent, for it combines the size and breadth of the Hawaiian type with the high nasal root and straight septum of the European.

Hair. (Table 34.) The hair color of the European parents of the hybrids of our sample is problematical. It is safe to say that in

TABLE 34. DESCRIPTION OF THE NON-MENSURABLE TRAITS OF 26 F_1 HYBRIDS BETWEEN HAWAIIAN FEMALES AND NORTH EUROPEAN MALES

		♂	♀
Hair color	Black 12, Dark brown 8, Brown 5, Reddish brown 1		
Hair form	Wavy 17, Curly 4, Straight 3, Frizzy 1.		
Eye color	Brown 12, Light brown 10, Dark brown 2, Hazel 1, Blue 1		
Eye fold	Not observed		
Skin color	Broca's grades 23 and 24		
Nose form	Root high	5	3
	straight	6	8
	depressed	1	2
	Bridge straight	8	10
	concave	2	3
	convex	2	..
	Septum straight	10	8
	up	2	5
Lips	Thick 4, Medium 7		
Prognathism	Absent 8		
Brow ridges	Prominent 2, Slight 4, Absent 2		

average shade it is somewhat lighter than the hair color of the Hawaiians which is prevailingly black. The hybrids likewise have generally black or dark brown hair, although the average shade is probably lighter than among pure Hawaiians. One hybrid (no. 221) had reddish brown hair of the Ehu type, and it is known that the mother of this subject was a Red Hawaiian. The hair color of the white father was not known, but he was probably blonde or carried a recessive blondness. The pedigree of this girl was somewhat doubtful and full credence cannot be placed in the record. It is probably not an exception to the general statement that no light haired hybrids result from matings of dark-haired Hawaiians and Europeans.

The chief difference between the parent races in hair form is probably in the higher incidence of straight hair among the European parents. The Hawaiians have predominantly wavy or curly hair. The distribution of hair form among the hybrids is almost the same as among the Hawaiians, indicating probably partial dominance of the wavy or curly type. One F_1 female (no. 232) had hair with narrow close waves, designated as frizzy. Her nine children by a wavy-haired F_1 male (no. 128) consisted of four wavy-haired, three curly-haired and one straight-haired (one not noted), indicating that frizzy hair is probably a form of curly, possibly artificially deformed. Three examples of this hair type were found among pure Hawaiians, all females.

Eye Color. (Table 34.) The eye colors found among Hawaiians were chiefly brown and dark brown, although two anomalous individuals were noted with light colored brownish blue eyes. We have no data on the frequency of light brown and blue eyes among the European parent types, although the average shade of eye color was probably lighter than among the Hawaiians. The hybrids are intermediate in this respect, the eye color of most of them being brown and light brown (84 per cent). Two (8 per cent) had darker eyes, and a similar number had lighter eyes (one hazel and one blue). One of these subjects (no. 149) was similar in other traits to the other hybrids, while the other (no. 417) was tall with a narrow head, long face, and narrow nose, characters which are not entirely compatible with the parentage as given, and indicate that she probably belonged to a later generation from the cross of Hawaiian and white. These subjects are anomalous in the same sense as the two Hawaiians with light eyes, and no further evidence on these exceptions is available in the data.

Skin Color. (Table 34.) Our evidence on skin color, unfortunately, is not very satisfactory, and this is one of the most noticeable traits in which the Hawaiians and Europeans differ. There are available skin color records of twelve hybrids, determined by comparison with Broca's scale. The skin color of three of these corresponded with grade 24, while 9 were of grade 23 or slightly lighter. These were the two modal grades for the 75 Hawaiians recorded on this scale, and this fact would indicate a close resemblance of the hybrids to the average Hawaiian skin color. However, this conclusion is not confirmed by the few comparisons made with the better scale of von Luschan. Of the 3 hybrids recorded on this scale 2 were lighter (grades 7 and 10) than any of the pure Hawaiians. The skin color of the hybrids is unquestionably darker than that of the average European, but probably not so dark as the pure Hawaiian type.

Other Traits. A few descriptive observations of some other traits were made on some of the hybrids observed in 1916. These are given in Table 34, but are too few and scattering to add significantly to the hybrid description. A general summary of the characters of the hybrids will follow the descriptions of later generations from this cross.

The Second Generation

Twenty-eight subjects were found which gave their parentage as "father $\frac{1}{2}$ white, $\frac{1}{2}$ Hawaiian; mother $\frac{1}{2}$ white, $\frac{1}{2}$ Hawaiian." Assuming that both parents were F_1 hybrids (and in many cases it was established that this was so), these individuals should constitute the second generation from the cross of Hawaiian by North European, although some of them probably belong to later generations. It is in this group that the segregation of traits in which the parent types differed should be most apparent. Only seven of this group were mature when measured, 3 males and 4 females, and the group as a whole is too small to yield reliable averages or variation constants of mensurable traits. However, the group includes one family of 9 children, all immature, resulting from the marriage of 2 F_1 hybrids (male no. 128 $\times$ female no. 132). A complete series of observations is available for each of the parents and the children.

By reference to these individual observations (Appendix Table IV) we shall attempt to determine the extent of segregation and recombination of single traits, without attempting any description of this generation as a whole. On account of the usually great variability of hybrid generations beyond the first, such a description would have to rest on a much larger material than is available at present.

In respect to stature and general body size, the data are too few and the parental differences too slight to make comparisons profitable. In head size and shape, however, the parent races were probably different, and for shape characters some of the immature F_2 subjects may be included, thereby increasing the numbers of observations. Among the 24 subjects of age 11 and over, the cephalic index ranges from 72 to 88 as compared with a range or 74 to 92 for the Hawaiians. The distribution of head form among the F_2 subjects as compared with the pure Hawaiians is as follows:

Table 35. Cephalic Index

	No.	−74.9 Per cent dolichocephalic	75−79.9 Per cent mesocephalic	80− Per cent brachycephalic
Hawaiian male and female...	1C8	2.1	9.8	88.
F_1 male and female	36	..	5.5	94.4
F_2 male and female.........	26	7.7[1]	34.6[1]	57.7

There are relatively more dolicho- and meso-cephalic heads among the F_2 hybrids than among either the Hawaiians or the F_1 hybrids. This probably indicates the segregation of recessive factors for longer headedness introduced by the white ancestors.[1] There is, however, no such evidence of the segregation of head shape in the F_2 family observed. Both of the F_1 parents had a cephalic index of 81, while the indices of the children of age 6 and over range from 76 to 81. Although still immature they have, on the average, slightly longer heads than their parents; but are grouped closely together and do not resemble a segregating distribution. Such a condition would arise if the particular white and Hawaiian parents involved did not differ much in head form.

[1] The per cent of dolicho- and mesocephalic in F_2 as shown in the table is probably too low, since some of the subjects included were immature, and the index may be expected to fall somewhat with increasing age.

The shape of the face varies in the F_2 subjects through the same range as in the Hawaiians, without distinct evidence of segregation. In nose form, however, there is an evident tendency for a return to the narrower condition characteristic of the European. The nasal index in the pure Hawaiians ranged from 68–102 (average 83 for males); in F_1 the range was from 62–98 (average 81 for males) while in F_2 only 4 individuals of age 15 and over exceed the F_1 average. The frequency of narrow noses of index 74 and under is unquestionably higher in the F_2 than in either the F_1 or Hawaiian distributions. This is apparently due to the segregation of recessive factors governing the absolute width of the nostrils, since nasal height is about the same in parent types, F_1 and F_2, and is unaffected by the cross. Descriptions of nasal root, bridge and septum are available for only 7 F_2 males of age 15 and over. In 6 of these the nasal root was straight and in one it was high. In none was it depressed. The resemblance here is to the F_1 males rather than to the Hawaiian parents. The condition of nasal bridge and septum is about the same as in the F_1 generation. Segregation of nose form in the F_2 family is made highly probable by the observations, since the nasal indices range from 62 to 90 (the parents had indices of 86 and 76). Five of the nine children had indices of less than 77, and when it is considered that these were immature subjects in which the nose is relatively broader than at maturity, it will be evident that the narrower type characteristic of the European shows a considerable tendency to reappear in the second generation.

Segregation of hair color is not very evident in this generation. Twenty-three individuals had black or dark brown hair while 3 had brown hair. Two had light brown hair while in one the hair was a very light brown, almost blonde. These light hair colors were not observed in the F_1 generation, and although the lightest haired F_2 was a very young child, they probably represent the reappearance of a recessive blondness introduced by the European grandparent. In hair form also there is little difference between this and the preceding generation. Wavy hair was observed in 20 cases, curly in 5, while straight hair appeared only 3 times. In the family observed the father had wavy and the mother frizzy (probably a variety of curly) hair while of the 8 children observed for this trait 4 had wavy, 3 had curly, and 1 had straight hair. The last is probably the recessive type.

Although most of the F_2 subjects had eyes of some shade of brown (brown 12, dark brown 7, light brown 5) as in the F_1 generation, the frequency of blue and hazel eyes was somewhat higher (1 hazel and 3 blue). This evidence of the reappearance of a recessive blondness is borne out by the occurrence of several F_2 subjects with very light skins. In the one F_2 family observed, the F_1 parents had skin of about the average shade of pure Hawaiians, while of the F_2 children 6 had skin as dark or slightly darker than the parents, while 3 had very light skins, practically white, and 1 of them was distinctly of the blonde type.

In general there is some evidence of the reappearance in the second generation of several traits such as longer head shape, narrower nose, and the lighter types of pigmentation, which from the F_1 evidence appeared to be recessive in inheritance. Because of the diverse combinations in which these traits reappeared, the second generation is much more variable than the first, although the small numbers preclude a quantitative analysis of this point or of the statistical relations between the various types and combinations.

Backcross Generations

Our observations on progeny of matings of hybrids with either Hawaiians or Europeans are more numerous than the observations on progeny of matings of hybrids inter-se. The data include descriptions of 42 individuals with 1 pure Hawaiian parent and 1 hybrid parent; of 23 individuals with 1 European and 1 hybrid parent; and of 16 individuals with variable proportions of white and Hawaiian blood who cannot be properly placed in any of the above classes. It is apparent from the relative numbers encountered in our sample and from the marriage statistics that persons with part Hawaiian blood more often marry members of one of the parent races, than others part Hawaiians like themselves. Of the group with 1 Hawaiian and 1 hybrid parent, the Hawaiian parent was the mother in 24 cases and the father in 18 cases. Of the group with 1 European and 1 hybrid parent, the European parent was in all cases the father. No offspring of matings between a European woman and a part Hawaiian man were found. The original observations of these subjects are given in Appendix Table IV, where they have been grouped according to the mating involved, and on the basis of sex and maturity. Those individuals descended from matings of hybrids with pure Hawaiians are classed as "BC (backcross) × Hawaiian"; the reciprocal group as "BC × white." All individuals included in either BC group had one parent of pure race. As in the other tables, those matings in which a European ancestor was Portuguese are specially designated (P) and follow those in which the white parent was a North European. The "BC × Hawaiian" group consists chiefly of individuals from matings of F_1 ($\frac{1}{2}$ Hawaiian, $\frac{1}{2}$ white) by Hawaiian, although a few are included in which the hybrid parent was $\frac{3}{4}$ Hawaiian, $\frac{1}{4}$ white. In general these backcross subjects have about $\frac{3}{4}$ Hawaiian and $\frac{1}{4}$ white blood. Similarly the individuals in the "BC × white" group are in general $\frac{3}{4}$ white and $\frac{1}{4}$ Hawaiian. Neither of these generations then represents a "backcross" in the strict sense of matings between F_1 hybrids with a pure parent type, and the questions concerning segregation of traits in numerical proportions which might be solved from such a generation, strictly defined, cannot be answered from the present data. The data on these generations, however, are useful in determining in how far the physical traits of the backcross groups differ from those of the pure Hawaiians and of the first generation hybrids. Wherever significant differences appear, these may be ascribed to inheritance from the white ancestors involved, and they should be more pronounced in those individuals which are $\frac{3}{4}$ white than in those which have but one quarter of white blood. Some indications of the manner of inheritance of the traits observed should be yielded by a comparison of the backcross groups with each other and with the parent groups, since, for example, any Hawaiian traits appearing in the "BC × white" group may be assumed to be dominant in inheritance while the appearance of white traits in the "BC × Hawaiian" group may likewise be ascribed to some degree of dominance of the trait in question.

The most profitable results, therefore, may be obtained by a direct comparison of the physical characters of the backcross generations with those of the Hawaiians and of the F_1 hybrids.

The best description of the mensurable traits of the "BC × Hawaiian" group is available from the measurements of 12 adult females, of $\frac{3}{4}$ Hawaiian and $\frac{1}{4}$ white blood. Only 4 adult males of this type were encountered. Brief reference to the characteristics of these will be made in the course of the comparison, but it is of little value to average their measurements. For the measurements of the "BC × white" group we have only the data on 6 adult females, and again a small group of 4 adult males. For non-mensurable traits we may include the whole "BC × Hawaiian" group of 33 individuals from crosses with North European, and the 19 subjects of the "BC × white" (North European) group. It is safer not to include in these groups individuals with Portuguese blood in the ancestry, because of the occasional appearance of negro traits in individuals of this descent. The mensurable traits are compared in Table 36; the non-mensurable traits are given for each group separately in Tables 37 and 38, and compared in Table 39.

Comparison of Mensurable Traits. In Table 36 appear the average measurements and the range of variability of 34 Hawaiian females, 12 BC × Hawaiian females of $\frac{3}{4}$ Hawaiian and $\frac{1}{4}$ North European blood, and 6 BC × white females of $\frac{1}{4}$ Hawaiian and $\frac{3}{4}$ North European blood. Acromic height and arm length measures are not included, since there was practically no difference between the parent races in these dimensions. The probable errors and variation constants have not been appended since these could have no significance with such small numbers of subjects and since there is no intention of drawing conclusions from the absolute differences between the averages. We shall only attempt to determine whether there is any tendency toward change in the averages in going from pure Hawaiians to those with but one quarter of Hawaiian blood.

A general view of the averages is sufficient to indicate that there are no great differences between the bodily dimensions of these three groups, and this was hardly to be expected in view of the similarity of the parent races in size. The four possibly significant indications however are (1) the lower average weight of the $\frac{3}{4}$ white group; (2) the tendency for the cephalic index to decrease in passing from the Hawaiian to the $\frac{3}{4}$ white group; (3) the lower average of nose breadth and nasal index in the $\frac{3}{4}$ whites; (4) the somewhat narrower and relatively higher faces of the subjects with more white blood. In respect to the first it was found that the Hawaiians were marked by stoutness, having a relatively higher index of bodily fullness (Index 1.53 males). The same tendency was observable in F_1 (Index males 1.68) and is evident in the $\frac{3}{4}$ Hawaiians females. The index for the $\frac{1}{4}$ Hawaiians is much lower, but for two

Table 36. Comparison of Averages of Mensurable Traits of Hawaiian Females with Hybrid Females containing 3/4 Hawaiian and 1/4 White Blood and 1/4 Hawaiian and 3/4 White Blood

	34 females Hawaiian		12 females BC × Hawaiian (3/4 Hawaiian, 1/4 White)		6 females BC × White (1/4 Hawaiian, 3/4 White)	
	Average	Range	Average	Range	Average	Range
Weight, lbs.	153.1	112 –235	157.8	95 –197	126.4	110–137
Stature, cm.	162.6	150 –175	161.9	154 –172	164.7	159–171
Sitting height, cm.	86.3	81 – 92	86.4	82 – 90	87.3	80– 93
Index of sitting height, %	53.1	50.5– 56.5	53.3	51.7– 55.1	53.0	50– 54.7
Head length, mm.	178.8	162 –198	174.6	164 –182	178.8	171–187
Head breadth, mm.	150.3	137 –161	144.2	138 –156	143.0	130–151
Cephalic index, %	84.2	73.8– 90	82.6	78.6– 92.7	79.9	76– 85.8
Bizygomatic diameter, mm.	136.7	123 –150	130.4	122 –143	129.5	117–137
Nasion-menton height, mm.	116.2	101 –125	112.5	99 –122	115.7	107–129
Facial index, %	85.1	76 – 92	86.3	78 – 92	89.3	84– 98
Nose height, mm.	51.2	43 – 58	48.6	41 – 53	52.0	41– 58
Nose breadth, mm.	40.9	35 – 49	38.9	36 – 42	32.5	30– 35
Nasal index, %	80.3	70 – 92	80.3	72 – 91	62.5	51– 79

reasons it cannot be certainly attributed to the inheritance of slighter body build from the white parent: (1) the F_1 ($\frac{1}{2}$ Hawaiian) and $\frac{3}{4}$ Hawaiian groups show no tendency to deviate in the direction of the lighter European average (2) the weights of the $\frac{1}{4}$ Hawaiians are derived from only five subjects all of whom were under 25 years of age, or before maximum weight is attained.

Table 37. Descriptions of Non-mensurable Traits of 33 Offspring of Backcross Matings between F_1 (Hawaiian × North European) and Pure Hawaiians

Hair color	Black 21, Dark brown 9, Reddish 1, no record 2			
Hair form	Wavy 23, Curly 6, Straight 3, no record 1			
Eye color	Brown 16, Light brown 7, Dark brown 9, Hazel 1			
Skin color	Broca's grades	24–7	von Luschan's grades	8–1
		23–5		9–1
		47–3		10–1
		39–2		12–2
				13–1
				14–1
				15–2
			♂	♀
Nose form	Root, high		3	2
	straight		7	7
	depressed		3	11
	Bridge, straight		8	10
	concave		1	8
	convex		4	2
	Septum, straight		10	7
	up		3	13
Lips	Thick 9, medium 8			
Prognathism	Absent 13, slight 2			
Brow ridges	Absent 13, slight 2, prominent 1			

The cephalic index falls from 84.2 in the Hawaiian females, to 82.6 in the $\frac{3}{4}$ Hawaiians, to 79.9 in the $\frac{1}{4}$ Hawaiians. The tendency indicated is toward longerheadedness in those individuals with more white blood. In attempting to establish whether this tendency is significant we have tabulated the cephalic indices of all of the $\frac{3}{4}$ Hawaiian and $\frac{1}{4}$ Hawaiian subjects (exclusive of Portuguese mixtures), combining the observations on subjects of age 13 and over and of both sexes. This is not strictly justifiable, but the sexual difference in the index is so small, it changes so little between age 13 and maturity, and the distribution of age and sex is so

Table 38. Description of Non-mensurable Traits of 19 Offspring of Backcross Matings between F_1 (Hawaiian × North European) and Pure Whites

Hair color.........Black 1, Dark brown 5, Brown 8, Light brown 3, Light yellow 1, no record 1
Hair form.........Wavy 7, Straight 6, Curly 1, no record 5
Eye color.........Dark brown 3, Brown 4, Light brown 3, Hazel 1, Blue 6, no record 2
Skin color.........Broca's grades..23–6
24–1
"light"–2

		♂	♀
Nose form	Root, high	5	1
	straight	4	3
	depressed	1	1
	Bridge, straight	7	5
	concave	2	..
	convex	1	..
	Septum, straight	6	2
	up	3	3
	down	1	..

Lips..............Thick 2, medium 6, thin 1
Prognathism.......Absent 8
Brow ridges Absent 5, slight 3, prominent 1

similar in the groups to be compared as to result in but little distortion of the data. The results are given in Table 39.

In spite of the small differences between the means of the adult indices, the $\frac{3}{4}$ Hawaiians and $\frac{1}{4}$ Hawaiians do show distinct differences in the frequency of different headforms. Longer or medium heads are more frequent in those with most white blood, while the short or round head forms are most frequent in those with most Hawaiian blood.

The difference in mean nasal index between the subjects with $\frac{3}{4}$ and with $\frac{1}{4}$ Hawaiian blood is probably significant although based on very few observations of the latter type. Examination of the individual indices of all subjects of both sexes and of age 13 and over shows that over 35 per cent of the $\frac{1}{4}$ Hawaiians had narrow

Table 39. Percentage Distribution of Cephalic Index

	No.	–74.9	75–79.9	80–84.9	85–89.9	90–
3/4 Hawaiian	(29)	...	38.0	34.5	24.1	3.4
1/4 Hawaiian	(19)	21.0	58.0	15.8	5.2	..

noses with index of 65 or below while only 10 per cent of the $\frac{3}{4}$ Hawaiians had such narrow noses. This index (65) marks the approximate lower limit of variation in shape of nose among the pure Hawaiians, since only three immature subjects out of 157 pure Hawaiians had noses as narrow as this. The appearance of narrow noses in the generation arising from a backcross of F_1 hybrids with the European parent type is probably due to the segregation of the narrow European nose form as a recessive, which agrees with the evidence from the F_1 generation.

The possible differences in the relative height and width of the face in the different hybrid groups has also been tested by examining the individual facial indices of all of the subjects. In the "BC ×Hawaiian" ($\frac{3}{4}$ Hawaiian) group about one third of all of the subjects have indices of the high or leptoprosopic type (above 88 per cent), while in the "BC × white" ($\frac{1}{4}$ Hawaiian) group nearly half have high faces of this type. The difference in the mean facial index of the two groups is small, as is also the difference between the two parent types, but there seems to be some tendency for the slightly narrower, higher face of the European to be recessive in inheritance.

In Table 40 appears a comparison of the backcross generations with the Hawaiian and F_1 generation in respect to hair form and color and eye color. The generations are arranged in the table in order of decreasing amount of Hawaiian blood, and the per cent of each generation falling into each descriptive class is given. In this table the conclusions already indicated by the F_1 and F_2 data are confirmed and in addition there is evidence of segregation of several North European recessive traits. In general, the frequency of the typically Hawaiian condition of the trait decreases with the increasing proportion of white blood. Thus in hair color the frequency of black hair falls from about 90 per cent among the Hawaiians to about 5 per cent among those subjects with $\frac{1}{4}$ Hawaiian and $\frac{3}{4}$ white blood, while the frequency of lighter shades of hair rises correspondingly with the increase in proportion of white blood. One clear blonde segregate occurs in the "BC × European" group, while the presence of individuals with light brown hair in this group and their absence from all the others indicates that this color also appears as a recessive introduced by the European ancestor. The red-brown hair which appears in 3 of the groups is of the Hawaiian

TABLE 40. COMPARISON OF THE COLOR AND FORM OF THE HAIR AND OF THE COLOR OF EYES IN HAWAIIANS AND IN HYBRIDS OF HAWAIIANS AND NORTH EUROPEANS

Percentage Distribution of Hair Color

	Hawaiian	No.	Black	Dark Brown	Brown	Light Brown	Red Brown	Yellow
Hawaiian	4/4	154	91.6	5.8	.6	...	1.3	...
BC F_1 × Hawaiian	3/4	31	67.7	29.0	...	...	3.2	...
F_1	2/4	25	44.0	32.0	20.0	...	3.7	...
BC F_1 × North European	1/4	17	5.5	27.8	44.4	16.7	...	5.5

Hair Form

	Hawaiian	No.	Curly	Wavy	Straight
Hawaiian	4/4	149	29.5	61.7	8.7
BC F_1 × Hawaiian	3/4	32	18.7	71.9	9.4
F_1	2/4	23	17.4	70.0	12.6
BC F_1 × North European	1/4	14	7.1	50.0	42.9

Eye Color

	Hawaiian	No.	Dark brown	Brown	Light brown	Hazel	Blue
Hawaiian	4/4	155	43.9	43.2	11.6	.6	.6
BC F_1 × Hawaiian	3/4	33	27.3	48.5	21.2	3.0	...
F_1	2/4	25	8.0	48.0	36.0	4.0	4.0
BC F_1 × North European	1/4	17	17.6	23.5	17.6	5.9	35.3

("Ehu") type and has apparently not been introduced by the immediate European cross. In hair form, the frequency of the Hawaiian curly type decreases, and of the European straight type increases with decreasing amount of Hawaiian blood. The eye color becomes progressively lighter in passing from Hawaiians to those with only $\frac{1}{4}$ Hawaiian blood, culminating in the appearance of blue and hazel eyes in over 40 per cent of the "BC × European" group. The lighter colors of hair and eyes, and the straighter hair form introduced by the European ancestors are apparently behaving in this as in other crosses as recessives, although it is evident that dominance is not complete in respect to any of them.

The descriptions of other non-mensurable traits of the backcross groups are given in Tables 37 and 38. There are too few of these to permit of any conclusive statements. The skin colors of the "BC × Hawaiian" group are apparently similar to those of the pure Hawaiians, while of the 9 observations of the "BC × white" group, 2 were recorded as "light," presumably of the European type, while 6 were somewhat lighter than the modal shade for Hawaiians. Several subjects in each backcross group were described as having the high nasal root of the European type. The presence of this type in the "BC × Hawaiian" group with $\frac{3}{4}$ Hawaiian blood confirms the F_1 evidence that the high nasal root behaves as a dominant. The Hawaiian type of low or depressed nasal root was rare in the "BC × white" group and more frequent in the "BC × Hawaiian" group.

Hybrids of Hawaiians and South Europeans

The number of subjects descended from matings between Hawaiians and Portuguese or Spanish is too small for detailed analysis (20 with some Portuguese blood, 5 with some Spanish blood), although the physical features of this group differ somewhat from those of the Hawaiian-North European hybrids. The chief argument for considering the Portuguese hybrids separately was the frequent evidence of negro admixture in subjects reporting themselves of Portuguese descent. The Portuguese in Hawaii, as has been noted, have come chiefly from the Cape Verde Islands and many of them are thought to be either negroes or negro-Portuguese hybrids. In our material several negroid traits appear in "Portuguese" and Spanish hybrids. No. 313, $\frac{1}{4}$ Spanish, $\frac{3}{4}$ Hawaiian (Table IV, BC × Hawaiian female), for example, was noted by the observer as possibly part negro and the description confirms this suspicion. This woman had very long arms (arm index 49.6, the highest in our material), a very small head, a small, narrow, long face and dark skin. No. 442 ($\frac{3}{8}$ Portuguese, $\frac{5}{8}$ Hawaiian), showed less distinctly negroid features, but had a low broad nose (index 94) and kinky black hair. No. 432, ($\frac{1}{4}$ Portuguese, $\frac{3}{4}$ Hawaiian), had a typically negroid nose, with a high index, low root and upturned septum. In addition to these subjects 5 others representing crosses of Hawaiian and negro were observed. Their measurements are given in Appendix Table VI. In the case of 3 of these the negro ancestor was traced to the Cape Verde Islands and was said to be "Portuguese." Each of these had kinky black hair; one had long arms (index 47.2) with a relatively short trunk (index 50.2) and a narrow high face. Other negroid features similar to those noted among the Portuguese hybrids were in evidence.

The principal peculiarities of the Portuguese hybrid group as a whole as compared with the North European hybrids, are their smaller size, the greater frequency of individuals with relatively long arms, sometimes combined with a rather short trunk, and their narrower and frequently higher faces. Thus 4 mature males F_1 Portuguese × Hawaiian averaged 155 pounds in weight and 166 cm. in height, compared with 194 pounds and 173 cm. for the North European F_1 group. The face width of the Portuguese group was 134 mm. while the northern group averaged 145 mm. The narrower face seems to obtain throughout the whole group of Portuguese hybrids, although because of somewhat greater facial height, the facial index is about the same as in the northern group. We have no good evidence from which to form an estimate of the physical features of the Portuguese parents. Our own material includes descriptions of 9 Portuguese observed in Hawaii, although only 4 of these were adult, all females (see Appendix, Table VI). From these and other observations (cf. Martin), it is apparent that the Portuguese parents are shorter (average height males about 165 cm.), and smaller than the North European parents or the Hawaiians. In bodily proportions they probably do not differ significantly from the North Europeans or Hawaiians; in head shape they are mesocephalic (average head index about 78–80). Their nose form, where not affected by negro mixture, is probably similar to that of the North Europeans, i. e. index about 65, with high root and straight bridge. The shorter stature and size of the Portuguese-Hawaiian hybrids indicates the absence of dominance which obtains in most dimensional characters; while the narrower face is probably an expression of their generally smaller size, since the facial index is about the same for the Portuguese as for the North European hybrids.

Other Hawaiian-White Mixtures

Observations were made of a number of Hawaiian-white hybrids which could not be classified in any of the groups discussed above, chiefly because of the greater complexity or incompleteness of the pedigrees. The original data on these are given at the end of Appendix, Table IV. For the most part these subjects represent a more advanced stage of race mixture than the F_2 or backcross groups, and they form a rather variable group, showing many different combinations of Hawaiian and European traits. The pedigree of No. 290, for example, indicates that she probably is of the third hybrid generation. She resembles a pure Hawaiian in most of the traits observed. Likewise No. 33, although half white, probably is of the third hybrid generation, and appears to be a typical Hawaiian. No. 167 on the other hand is $\frac{3}{4}$ white, yet has a low broad face, and resembles the Hawaiian type in body build, but has the high nose and lighter hair and eyes more characteristic of the European type. The occurrence of different combinations of traits in this heterogeneous group bespeaks some measure of independent segregation of the heritable features of each racial type. Aside from this, the group does not add anything to our knowledge of the inheritance of the traits in question.

SUMMARY AND DISCUSSION

The European and Hawaiian types which have intermarried in Hawaii are very similar in bodily dimensions and proportions, except for the greater corpulence of the Hawaiians. The F_1 hybrids and those with $\frac{3}{4}$ Hawaiian blood resemble the Hawaiians in this respect, although there is not enough evidence on the weight either of the European type when living under Hawaiian conditions or of hybrids of later generations to permit the conclusion that the tendency to corpulence is inherited as a dominant, or that it is due to diet and habits of life.

There is distinct evidence of the inheritance of the brachycephalic head shape of the Hawaiians as a dominant, and of the reappearance of the European type of head as a recessive in later hybrid generations. The Hawaiians have broader noses than the Europeans, and this characteristic appears likewise in the hybrids. It possibly depends on dominant factors, although the size of a soft part such as the width of the nostrils must depend to some extent on the relative fleshiness of the face, and thus indirectly and partially on the same environmental conditions which conduce to greater corpulence. The shape of the root of the nose probably is affected less or not at all by such conditions, and the differences between the lower and frequently depressed root of the Hawaiian nose and the higher, narrower root of the European type probably depend on heritable factors. In this trait there is good evidence of the dominance of the higher European type. It is possible that these two parts of the nose are affected by different factors, since the broader nostrils of the Hawaiian and the higher root of the European appear together in some of the F_1 hybrids, indicating that the Hawaiian condition of the one part (nostrils) may be dominant; while of the other part (root) is probably recessive.

The darker hair color, wavier hair form, and darker shade of eyes and skin of the Hawaiian type are partially dominant. Straight hair, and blondness of hair, eyes, and skin reappear as recessives in segregating generations (F_2 and backcross). As a whole, the F_1 hybrids bear a closer resemblance to the Hawaiian than to the European parent type, and it seems that in the traits observed, the Hawaiians contribute to the cross relatively more dominant factors than the Europeans. Such evidences of the dominance of the factors contributed by this or that parent type are, however, of relatively minor importance, since in most of the traits observed dominance was incomplete, the hybrid occupying a position intermediate between the parental conditions of the trait. The more significant features of the results are the evidences of segregation of "racial" characters such as nose form, head form, hair and skin color in diverse combinations in the F_2 and backcross generations. The evidences of Mendelian inheritance in such traits do not extend to the ratios obtained, and this is not to be expected from the data at present available. Factorial analyses supported by clear segregation ratios can be expected to appear only in data involving large numbers of F_2 or backcross progeny, obtained from complete family records in which the description of each trait in each ascendant is known.

Nor do the data throw much light on the important question of the relative number of hereditary differences between the Hawaiians and Europeans. In the dimensional traits such as stature and length of parts, there appears to be very little difference; in the shape of the nose there is a distinct and apparently wide difference, yet from the behavior of nose shape in inheritance, this seems to be determined by relatively few factors, so that the divergence may have been brought about by only a few hereditary changes. In general those features in which the Hawaiians differ most markedly from the Europeans (color of skin, hair and eyes, form of nose and face) are those in which the Hawaiians and Chinese are most alike.

Thus the chief divergence of Hawaiians and Europeans is in the more Mongoloid features of the Hawaiians. These are few in the present case, possibly because some distinctly Mongoloid features were not observed (such as relative hairiness of head and body). The data thus appear to show relatively fewer differences between the Hawaiian and European than between the Hawaiian and Chinese, and indicate for the Hawaiians a position (in respect to number of hereditary differences) intermediate between Europeans and Mongoloids, with somewhat closer affinity to the European. In any event, the number of differences between the Hawaiian on the one hand and the Europeans or Chinese on the other appear to be definitely fewer than those between the European and the Chinese. Finally, it should be remembered that the criteria for judging the number and importance of racial differences, viz., the results of factorial analysis of the separate traits, can at present be applied only in a fragmentary and tentative way, because of inadequate evidence on inheritance and ignorance of the effects of diverse environments on most of the traits commonly observed.

The results of study of the Hawaiian-Chinese and Hawaiian-European crosses confirm the already considerable evidence that (1) all physical characters of the kind observed are quite variable even in pure racial groups; (2) this physical variability is somewhat increased in the hybrids, chiefly through the formation of different combinations of characters, although the hybrid groups cannot be distinguished from the "pure" types merely by increased variability in single traits; (3) there are few or no constant or infallibly distinguishing marks of any of the races or hybrid groups studied. From the observations recorded, all of these types appear to have much in common, and the heritable physical differences are fewer than one would have been led to expect from a knowledge of the previous geographic isolation of the groups and of the absence of recent intercrossing between them. So far as the measurements go, there appear to be no absolute criteria of race or of stage of mixture. The results of crosses between "races" show that "race" as it applies to a congeries of physical characters, must be used only in a relative or comparative sense, since "races" as such do not segregate from crosses, but break up into their separate component features. Thus from the crossing of races in Hawaii there emerges a heterogeneous population which does not contain distinctly Hawaiian, or Chinese, or White individuals, although many may reproduce the Hawaiian, or Chinese or white condition of one or a number of traits. Such a group departs from its parent types not so much in "racial" traits, but rather by exhibiting in its physical features the potentialities for the development of a future more uniform type which may be more or less Hawaiian, or Chinese, or white, depending on combinations of circumstances which cannot at present be foretold.

Racial Classification of the Subjects

A. Pure Races		B. Hawaiian-"White"[1] Hybrids		C. Hawaiian-Chinese Hybrids	
Hawaiian	157	F_1	36	F_1	28
Chinese	23	F_2	30	F_2	6
Portuguese	9	Backcross × Hawaiian	42	Backcross × Hawaiian	28
Japanese	8	Backcross × White	23	Backcross × Chinese	5
Korean	4	Other mixtures	16	Other mixtures	8
Filipino	2				
Totals	203		147		75

D. F_1 Hawaiian		E. Tri-Racial Hybrids		F. Multiple and Other Hybrids	
Negro	5	Haw. Chinese White	27	Haw. Port.[3] Tahitian White	1
Japanese	4	Haw. Indian White	4	Haw. Chinese Negro White	1
Samoan	3	Haw. Malay White	2	Haw. Indian Japanese White	1
Filipino	1	Haw. Japanese White	2	Part Hawaiian	8
Indian	1	Haw. (other)[2] White	6	Non-Hawaiian hybrids	7
Hindu	1	Haw. Japanese Samoan	1	Unclassified and omitted	8
Totals	15		42		26
Total for all groups					508

[1] Including Portuguese and North European.
[2] Including one each of Syrian, Hindu, Tahitian, Negro, Portuguese (negro?) and Filipino and "East Indian."
[3] Probably part Negro.

Nativity of Hawaiian Subjects

Subjects listed as pure Hawaiians are natives of Oahu except for the following:

Males

Subject No.	Native of
14	Maui
279	Molokai
282–284	Hawaii
343–344	Maui
345–346	Hawaii
351–352	"
355–356	"
358–359	"
360	Maui
361	Hawaii
363	Maui
366	"
371	"
374–375	Hawaii
379	Hawaii
380	Kauai
381	Maui
386	Maui
389	Kauai
393	Maui
396	Kauai

Females

Subject No.	Native of
286	Maui
287	Molokai
289	Hawaii
294	Kauai
299	Molokai
304	Maui
311	Hawaii
318	Hawaii
319	Kauai
322	Maui
331	Hawaii

Occupational Distribution of the Subjects described in Appendix, Tables I–IV

Subject No.	Occupation
1– 22 99–114 128–136 169–174 183–193 232–233 274–276a 333 401–425 501–506	Unclassified subjects measured at gathering places such as churches, beaches, homes, etc., probably representing a random sample of the population in respect to occupation.
23– 56 88– 98	School boys and girls — Hameameha school
57– 61 86– 87 137–138 163–168 178–182	Palama settlements
62– 85	Students — Mills Schools
115–122 153–162	Y. W. C. A. and Kindred settlements
123–127	Y. M. C. A. — Swimmers
139–143 145–146	Fishermen
144 147–152 175–177	Policemen
194–231 234–273	Students — Girls' Industrial School
277–332 334–342	Students — Summer school
343–400	— Stevedores
426–500	— Workers in pineapple factories

Note to Table IV, Appendix

In this and the following tables, information on the parentage of each subject is given in the column headed "pedigree." The following abbreviations are uesed to designate race (or nationality) of the parents.

Am ...	White American	K.....	Korean
C.....	Chinese	M.....	Malay
Ca....	Canadian	N.....	North European
E.....	English	Ne....	Negro
F.....	Filipino	No....	Norwegian
Fr.....	French	P.....	Portuguese
G.....	German	Sa.....	Samoan
H.....	Hawaiian	Sc.....	Scotch
I......	Amerindian	Sw....	Swedish
Ie.....	East Indian	Sp.....	Spanish
Ir.....	Irish	T.....	Tahitian
J......	Japanese	W.....	White (usually North European)
Je.....	Jewish		

The mother's race is given before the line; the father's after.
Thus HE/H indicates that the mother was 1/2 Hawaiian, 1/2 English and the father was Hawaiian.

APPENDIX

TABLE I. RAW DATA FOR THE STUDY OF THE ANTHROPOMETRY OF PURE HAWAIIANS

Adult Males

Subject No.	Age	Bodily Measurements in Cm.								Head Measurements in Mm.			
		Weight lbs.	Stature	Height of Acromion	Height of Dactylion	Height Sitting	Arm Length	Index of Arm Length %	Index of Ht. Sitting %	Length	Breadth	Cephalic Index %	Min. Frontal Diam.
4[1]	43	...	170.8	140.4	59.5	87.0	80.9	47.36	50.94	186	161	86.56	122
14[2]	71	...	162.0	135.0	59.0	83.5	....	....	....	183	161	87.98	120
19[3]	42	...	169.5	139.5	60.0	85.0	79.5	46.90	50.15	175	155	88.57	128
99	42	...	....	....	....	....	....	....	....	194	163	84.02	124
140	47	...	160.8	132.5	60.3	86.8	72.2	44.90	53.98	182	151	82.97	114
141	60	185	170.2	138.0	62.2	87.8	75.8	44.53	51.59	198	158	79.80	115
143	28	185	178.4	147.0	66.0	93.2	81.0	45.40	52.24	192	159	82.81	129
146	59	216	176.9	147.8	64.8	90.4	83.0	46.92	51.10	199	163	81.91	122
148	35	185	185.5	151.2	62.8	96.4	88.4	47.65	51.97	195	154	78.97	121
150	48	230	176.7	147.0	66.1	93.1	80.9	45.78	52.69	192	159	82.81	124
151	23	202	170.4	140.5	64.9	91.4	75.6	44.37	53.64	187	160	85.56	127
152	41	200	173.5	141.5	62.3	93.2	79.2	45.65	53.72	201	163	81.09	123
175	25	147	170.5	140.0	62.2	89.7	77.8	45.63	52.61	188	165	87.76	118
176	47	...	181.8	148.8	67.4	96.0	81.4	44.77	52.80	190	159	83.68	120
183	27	...	169.5	135.5	59.8	86.5	75.7	44.66	51.03	178	152	85.39	116
186	29	147	175.0	141.7	60.9	88.8	80.8	46.17	50.74	203	155	76.35	122
187	32	169	170.8	138.9	62.2	87.7	76.7	44.91	51.35	186	163	87.63	124
188[4]	43	175	175.0	143.2	62.5	91.8	80.7	46.11	52.46	188	155	82.45	123
192[4]	43	...	160.6	132.2	58.1	83.5	74.1	46.14	51.99	194	156	80.41	115
279	27	168	176.9	145.6	64.4	92.2	81.2	45.90	52.12	186	150	80.64	...
282	21	160	166.4	136.0	60.5	87.4	75.5	45.37	52.52	185	150	81.35	...
283	22	160	172.4	142.2	65.5	89.3	76.7	44.49	51.80	176	147	83.52	...
284	43	150	169.0	139.2	65.5	89.9	73.7	43.61	53.19	191	156	81.67	...
317	35	270	169.4	139.8	63.6	89.3	76.2	44.98	52.71	199	159	79.90	...
333	53	...	176.5	146.4	63.3	....	83.1	47.08	....	176	154	87.50	...
343	?	182	164.5	132.3	59.2	92.2	73.1	44.44	56.05	175	147	84.00	...
344	25	135	165.0	136.5	61.9	89.0	74.6	45.21	53.94	169	141	83.43	...
345	36	151	167.9	136.4	60.5	92.4	75.9	45.20	55.03	181	150	82.87	...
346	28	168	164.3	133.2	61.0	86.1	72.2	43.94	52.40	176	145	82.39	...
349	25	138	165.4	134.5	60.9	89.9	73.6	44.50	54.35	163	146	89.57	...
351	43	185	165.4	137.3	59.5	89.3	77.8	47.04	53.99	183	156	85.24	...
352	32	145	167.7	135.4	63.3	90.2	72.1	42.99	53.79	180	159	88.33	...
355	21	140	172.4	138.7	59.1	85.8	79.6	46.17	49.77	173	147	84.97	...

[1] Husband of No. 5 (F_1 Hawaiian × Chinese); father of Nos. 6–15 (Backcross F_1 × Hawaiian).

[2] Father of No. 4. Bodily measurements of this subject not included in averages because of age.

The symbols used in describing the hair and eye colors of the Hawaiians are as follows: Br − 1 = light brown; Br + 1 = dark brown; Br + 2 = very dark brown.

APPENDIX

TABLE I. RAW DATA FOR THE STUDY OF THE ANTHROPOMETRY OF PURE HAWAIIANS

Adult Males

Face Measurements in Mm.								Descriptive				
Bizygomatic Diam.	Nasion Menton Ht.	Facial Index %	Nasion Prosthion Ht.	Bigonial Diam.	Nasal Ht.	Nasal Bth.	Nasal Index %	Skin* Color	Hair Color	Hair Form	Eye Color	Strength rt. lft.
157	123	78.34	73	130	56	42	75.00	47	Black	Curly	Brown	38–37
154	133	86.36	76	120	62	44	70.96	39	“	“	“	49–42[2]
148	112	75.67	67	119	50	41	82.00	40−	“	Wavy	Br+2	55–49
155	140	90.32	80	128	59	46	77.96	23+	“	“	Br−1	51–46
138	125	90.57	72	126	60	45	75.00	23−	“	Straight	Br−1	39–34
147	133	90.47	75	132	58	47	81.03	24	“	Wavy	Br−1	40–45
155	126	81.29	69	141	52	41	78.85	. . .	“	“	Br−1	61–55
150	121	80.66	64	135	52	48	92.31	. . .	“	“	Br+1	53–47
146	131	89.73	79	127	58	44	75.86	24	“	“	Br−1	63–66
157	137	87.26	76	141	61	44	72.13	24	“	Curly	“	52–48
158	124	78.48	78	142	56	39	69.64	24	“	Wavy	Brown	58–60
160	126	78.75	67	145	54	48	88.88	24	“	“	Br−1	61–59
156	128	82.05	66	127	59	46	77.96	25	“	“	“	48–54
154	140	90.91	79	142	59	48	81.35	39	“	“	“	62–55
140	127	90.71	80	124	61	44	72.13	. . .	“	Curly	Brown	49–49
146	126	86.30	74	128	53	43	81.13	. . .	“	“	“	62–62
144	127	88.19	73	131	53	42	79.24	. . .	“	Wavy	“	53–52
148	132	89.18	73	129	64	44	68.75	. . .	“	Curly	Br+1	54–48
144	132	91.66	74	130	57	46	80.70	. . .	“	“	Brown	52–43
135	117	86.67	68	. . .	53	42	79.24	*11*	. . .	Wavy	Br+1	56
135	110	81.48	71	. . .	52	45	86.54	*15*	Black	Curly	Br+2	54
132	104	78.79	60	. . .	46	41.5	90.22	*14*	“	“	Brown	69
140	122	87.14	75	. . .	53	47	88.68	*12*	“	Wavy	“	56
147	124	84.35	70	. . .	60	49	81.67	*15*	“	“	Br+1	56
140	123	87.86	71	. . .	55	52	94.54	. . .	“	“	Br+1	42
137	119	86.86	65	. . .	49	45	91.84	*19*	“	Curly	Br+1	46
126	119	94.44	75	. . .	55	41	74.54	. . .	“	Wavy	Brown	46
129	120	93.02	72	. . .	50	43	86.00	. . .	“	Curly	Br+1	38
123	113	91.87	67	. . .	52	45	86.54	. . .	Black	Wavy	Br+1	57
130	117	90.00	70	. . .	55	40	72.73	. . .	“	“	Br+1	36
142	125	88.03	70	. . .	54	44	81.48	. . .	Br+1	“	Br+Blue	61
138	122	88.40	68	. . .	52	43	82.69	. . .	Black	Straight	Br+1	64
132	131	99.24	80	. . .	59	43	72.88	. . .	“	Curly	Br+1	56

[3] Husband of No. 17 (Hawaiian); father of No. 20. [4] Nos. 188 and 192 are twins.

* Skin colors on Von Luschan's scale are given in italics; those on Broca's scale in Roman type.

TABLE I (continued)

Adult Males

Subject No.	Age	Bodily Measurements in Cm. Weight lbs.	Stature	Height of Acromion	Height of Dactylion	Height Sitting	Arm Length	Index of Arm Length %	Index of Ht. Sitting %	Head Measurements in Mm. Length	Breadth	Cephalic Index %	Min. Frontal Diam.
356	38	190	164.4	134.7	61.6	87.9	73.1	44.46	53.47	177	150	84.74	...
358	21	181	172.1	138.3	56.2	91.2	82.1	47.70	52.99	174	146	83.91	...
359	42	154	165.0	133.2	58.4	88.0	74.8	45.33	53.33	177	142	80.22	...
360	25	135	166.0	136.8	61.9	85.8	74.9	45.12	51.69	168	142	84.52	...
361	30	169	167.7	138.6	59.2	88.2	79.4	47.35	52.59	175	147	84.00	...
363	30	160	170.0	140.9	....	88.8	....	....	52.23	162	147	90.74	...
366	50	168	171.5	142.1	60.4	90.0	81.7	47.64	52.48	181	151	83.42	...
368	39	156	166.4	136.3	60.4	89.2	75.9	45.61	53.61	178	145	81.46	...
371	23	165	172.4	140.8	65.1	90.3	75.7	43.91	52.38	185	152	82.16	...
372	59	225	173.5	140.7	59.2	91.2	81.5	46.97	52.56	184	155	84.24	...
373	31	143	168.9	138.2	60.3	84.0	77.9	46.12	49.73	183	152	83.06	...
374	26	150	170.9	137.5	61.4	91.6	76.1	44.53	53.60	184	151	82.06	...
375	35	175	178.0	146.9	64.3	89.5	82.6	46.40	50.28	180	147	81.67	...
377	28	171	175.9	143.8	62.2	93.2	81.6	46.39	52.98	188	152	80.85	...
379	29	160	170.5	138.6	63.2	90.1	75.4	44.22	52.84	176	149	84.66	...
380	46	187	168.9	135.2	60.6	86.0	74.6	44.17	50.92	190	142	74.74	...
381	39	206	170.6	140.1	63.7	91.5	76.4	44.78	53.63	185	150	81.08	...
384	45	175	169.9	138.9	62.6	92.5	76.3	44.91	54.44	180	156	86.67	...
386	25	140	172.3	141.1	66.9	91.6	74.2	43.06	53.16	181	143	79.00	...
389	30	175	170.2	140.6	63.1	91.0	77.5	45.53	53.47	182	151	82.97	...
392	27	115	166.1	136.3	66.6	88.0	69.7	41.96	52.98	173	150	86.70	...
393	31	168	179.5	144.9	67.5	95.2	77.4	43.12	53.04	181	148	81.77	...
394[5]	23	145	170.7	135.5	59.9	91.5	75.6	44.29	53.60	171	151	88.30	...
396	37	152	175.9	145.2	62.0	93.5	83.2	47.30	53.15	182	149	81.87	...
397	20	139	166.2	134.9	60.2	87.5	74.7	44.94	52.65	169	156	92.31	...
402	42	150	169.0	137.6	60.3	89.9	77.3	45.74	53.19	190	151	79.47	...
404	39	183	170.2	140.2	63.4	91.9	76.8	45.12	53.99	171	150	87.72	...
406	67	150[6]	161.2[6]	131.6	60.5[6]	87.6[6]	....	....	....	179	154	86.03	...
407	28	190	170.5	139.8	63.5	90.5	76.3	44.75	53.08	183	154	84.15	...
409	49	142	171.0	140.1	61.7	91.0	78.4	45.85	53.22	176	147	83.52	...
410	60	200	166.6	136.8	60.5	90.4	76.3	45.80	54.26	187	157	83.96	...
412	69	...	176.2	143.2	64.8	92.5	78.4	44.49	52.50	190	154	81.05	...
413	41	135	167.1	136.8	64.4	87.1	72.4	43.33	52.12	177	149	84.18	...
415	58	170	182.2	151.2	68.0	96.1	83.2	45.66	52.74	178	151	84.83	...
416	25	135	168.6	138.1	61.0	86.1	77.1	45.73	51.07	183	144	78.69	...
419	62	194	177.8	147.8	61.7	90.4	86.1	48.42	50.84	178	149	83.71	...
420	65	175	170.3	139.9	61.4	92.0	78.5	46.09	54.02	179	146	81.56	...
422	66	...	168.4	139.0	60.1	84.9	78.9	46.85	50.41	177	146	82.48	...
423	36	165	178.6	146.5	63.9	95.4	82.4	46.14	53.41	180	152	84.44	...
424	64	...	152.9[6]	126.4[6]	50.6[6]	76.9[6]	....	....	....	174	146	83.91	...
9	33	...	180.8	149.0	69.0	92.0	80.0	44.25	50.88	198	159	80.30	...

[5] Red Hawaiian "Ehu." [6] Measurements omitted from averages.

TABLE I (continued)

Adult Males

Face Measurements in Mm.								Descriptive				
Bizygomatic Diam.	Nasion Menton Ht.	Facial Index %	Nasion Prosthion Ht.	Bigonial Diam.	Nasal Ht.	Nasal Bth.	Nasal Index %	Skin Color	Hair Color	Hair Form	Eye Color	Strength rt.
136	117	86.03	62	...	47	44	93.62	...	Black	Wavy	Brown	59
144	119	82.64	67	...	49	45	91.84	...	"	Curly	Br+1	57
137	114	83.21	64	...	45	44	97.78	...	"	"	Brown	58
128	114	89.06	62	...	46	38	82.61	...	"	Wavy	Br+1	55
135	110	81.48	70	...	52	41	78.85	...	"	"	Brown	82
138	113	81.88	64	...	49	46	93.88	...	"	Straight	Br+1	64
141	118	83.69	73	...	59	45	76.27	...	"	Curly	Brown	65
136	122	89.70	68	...	49	46	93.88	...	"	"	"	54
139	121	87.05	68	...	50	42	84.00	...	"	"	Br+1	51
145	119	82.07	70	...	51	48	94.12	...	"	"	Br+1	39
136	122	89.70	71	...	54	42	77.78	...	"	Wavy	Brown	61
137	122	89.05	72	...	49	47	95.92	...	"	Curly	Br+1	54
135	114	84.44	64	...	48	48	100.00	...	"	Wavy	Brown	61
141	129	91.49	78	...	59	42	71.19	...	"	Curly	Br+1	55
131	119	90.84	71	...	52	39	75.00	...	"	Wavy	Brown	51
132	125	94.70	67	...	53	47	88.68	...	"	"	Br+1	40
133	127	95.49	70	...	49	44	89.79	...	"	"	Brown	43
139	119	85.61	69	...	55	45	81.82	...	"	Curly	"	45
129	122	94.57	71	...	55	41	74.54	...	"	Wavy	Br+1	57
136	120	88.23	72	...	53	43	81.13	...	"	Curly	Brown	49
128	119	92.97	73	...	55	41	74.54	...	"	Wavy	"	43
136	122	89.70	79	...	55	42	76.36	...	"	Curly	"	52
141	121	85.81	75	...	57	42	73.68	...	Red Br.	"	"	62
133	112	84.21	67	...	51	42	82.35	...	Black	Wavy	Br+1	41
138	114	82.61	70	...	52	41	78.85	...	"	Curly	Brown	57
138	133	96.38	77	...	57	46	80.70	...	"	Wavy	Br+1	..
136	118	86.76	66	...	51	44	86.27	...	"	Straight	Brown	..
141	121	85.81	67	...	50	51	102.00	...	"	Wavy	Br−1	..
141	118	83.69	67	...	49	46	93.88	...	"	"	Br+1	..
135	124	91.85	71	...	58	48	82.76	...	"	"	Br+1	..
...	128	....	71	...	53	45	84.90	...	"	"	Brown	..
137	138	100.73	76	...	61	44	72.13	...	White	"	"	..
137	120	87.59	65	...	51	43	84.31	...	Black	"	"	..
141	126	89.36	77	...	58	43	74.14	...	"	"	Br+1	..
133	117	87.97	66	...	50	44	88.00	...	"	Curly	Brown	..
139	121	87.05	62	...	53	44	83.02	...	"	"	Blue[7]	..
142	123	86.62	72	...	55	46	83.64	...	"	Wavy	Br−1	..
130	121	93.08	65	...	49	42	85.71	...	"	"	"	..
136	118	86.76	65	...	53	43	81.13	...	"	Curly	Br.+1	..
132	129	97.73	65	...	52	51	98.08	...	"	Wavy	Brown	..
155	134	86.45	83	...	63	45	71.43	...	"	Curly	"	..

[7] Recorded as "almost blue."

TABLE I (continued)

Immature Males

Subject No.	Age	Bodily Measurements in Cm.: Weight lbs.	Stature	Height of Acromion	Height of Dactylion	Height Sitting	Arm Length	Index of Arm Length %	Index of Ht. Sitting %	Head Measurements in Mm.: Length	Breadth	Cephalic Index %	Min. Frontal Diam.
29	17	...	176.0	145.0	69.0	94.0	76.0	43.18	53.41	185	155	83.78	123
30	17	...	165.5	133.0	60.4	83.7	72.6	43.87	50.57	183	151	82.51	120
32	13	...	155.9	127.5	57.8	83.0	69.7	44.71	53.24	185	150	81.08	115
34	15	...	167.3	139.8	58.0	88.0	81.8	48.89	52.60	190	160	84.21	133
45	15	...	154.0	122.0	53.0	77.0	69.0	44.80	50.00	173	144	83.24	116
52	16	...	166.4	135.0	60.9	87.0	74.1	44.53	52.28	196	164	83.67	125
53	18	...	175.7	145.5	63.0	89.2	82.5	46.95	50.77	184	158	85.87	127
54	17	...	154.7	126.0	58.0	79.5	68.0	43.96	51.39	183	159	86.88	121
123	19	150	155.2	133.3	58.2	89.2	75.1	48.39	57.47	182	149	81.87	123
139	13	...	159.9	122.0	51.9	73.6	70.1	43.84	46.03	171	154	90.06	110
494	16	...	159.8	131.1	58.7	81.3	72.4	45.31	50.88	169	147	86.98	...

Adult Females

Subject No.	Age	Weight lbs.	Stature	Height of Acromion	Height of Dactylion	Height Sitting	Arm Length	Index of Arm Length %	Index of Ht. Sitting %	Length	Breadth	Cephalic Index %	Min. Frontal Diam.
16[8]	43	...	162.5	133.0	59.5	82.7	73.5	45.23	50.89	181	159	87.85	114
17	adult	...	164.5	134.5	63.3	84.0	71.2	43.28	51.06	180	161	89.44	115
18	21	...	151.5	124.0	53.7	81.0	70.3	46.40	53.46	180	159	88.33	117
57	21	...	164.9	133.1	62.4	84.3	70.7	42.87	51.12	195	144	73.85	112
87	23	115	166.8	137.5	64.0	85.8	73.5	44.06	51.44	189	158	83.60	118
91	19	...	163.7	133.1	63.2	87.3	69.9	42.70	53.33	192	153	79.69	124
101	46	...	164.2	133.5	61.9	90.6	71.6	43.61	55.18	181	154	85.08	115
104	48	...	169.2	140.8	64.2	87.3	76.6	45.27	51.59	177	148	83.62	114
105	67	...	161.5	133.2	61.8	87.8	72.4	44.83	54.36	185	151	81.62	112
106	18	...	162.5	132.3	58.5	85.9	73.8	45.41	52.86	184	152	82.61	123
107	53	...	166.2	135.3	62.0	88.4	73.3	44.10	53.19	184	151	82.07	117
108	47	...	156.6	128.6	61.0	82.4	67.6	43.17	52.62	186	155	83.33	108
110	30	...	165.7	134.5	58.9	85.9	75.6	45.62	51.84	178	145	81.46	116
112	31	...	162.3	129.8	59.8	88.1	70.0	43.13	54.28	196	154	78.57	113
153	23	147	163.6	134.5	62.0	83.1	72.3	44.19	50.79	183	159	86.89	115
161	19	158	160.0	131.9	59.6	86.4	72.3	45.19	54.00	198	161	81.31	115
162	18	...	161.7	132.5	60.2	86.6	72.3	44.71	53.55	180	149	82.78	118
286	35	235	167.0	137.6	68.0	91.0	69.6	41.68	54.49	171	152	88.89	...
287	51	160	160.9	131.5	60.5	86.0	71.5	44.44	53.45	175	147	84.00	..
289	22	158	163.9	135.0	61.8	87.9	73.2	44.66	53.63	179	148	82.68	...
294	23	140	157.9	127.1	65.6	87.7	....	....	55.54	171	150	87.72	...
299	35	150	167.9	139.3	65.4	89.3	73.9	44.01	53.19	172	145	84.30	...
304	30	180	162.1	131.5	64.2	89.4	67.3	41.52	55.15	171	146	85.38	...
311	27	145	163.0	131.9	61.7	92.4	70.2	43.07	56.69	169	149	88.16	...

[8] Sister of ♂ No. 4 (Hawaiian); mother of Nos. 17 and 18 following.

TABLE I (continued)

Immature Males

Face Measurements in Mm.								Descriptive				
Bizygomatic Diam.	Nasion Menton Ht.	Facial Index %	Nasion Prosthion Ht.	Bigonial Diam.	Nasal Ht.	Nasal Bth.	Nasal Index %	Skin Color	Hair Color	Hair Form	Eye Color	Strength rt. lft.
144	130	90.28	78	115	53	41	77.36	40−	Black	Wavy	Br+1	53–40
140	123	87.86	82	105	65	43	66.15	40−	"	"	Br+1	39–40
139	125	89.93	80	112	57	39	68.42	40	"	"	Brown	30–29
147	125	85.03	72	122	55	40	72.73	24	"	"	Br+1	56–50
137	119	86.86	73	110	48	40	83.33	47	"	Curly	Brown	26–24
144	125	86.81	78	122	56	39	69.64	39	"	"	Br+1	54–54
145	125	86.21	75	121	61	39	63.93	39	"	Wavy	Br.+1	45
144	118	81.94	71	117	56	41	73.21	40−	"	Curly	Br+2	33–35
141	128	90.78	78	118	62	39	62.90	39	"	Wavy	Br+1	52–58
136	111	81.62	65	110	48	38	79.17	25	"	Straight	Brown	25–24
128	111	86.72	71	...	48	40	83.33	...	Br+1	Straight	Br+1	34

Adult Females

Bizygomatic Diam.	Nasion Menton Ht.	Facial Index %	Nasion Prosthion Ht.	Bigonial Diam.	Nasal Ht.	Nasal Bth.	Nasal Index %	Skin Color	Hair Color	Hair Form	Eye Color	Strength rt. lft.
144	122	84.72	64	112	52	39	75.00	47	Black	Sl. curly	Br+1	30–29
142	114	80.28	63	112	54	39	72.22	24	"	Wavy	"	27–25
140	109	77.85	65	112	47	42	89.36	40−	"	V. curly	Br+2	35–33
134	118	88.06	75	113	52	41	78.85	...	"	Wavy	Brown	25–19
142	124	87.32	71	123	55	42	76.36	24	"	"	Br+1	34–27
143	127	88.81	74	118	55	40	72.72	24	"	Curly	Br+2	29–34
148	127	85.81	72	123	57	45	78.94	23	"	"	Brown	25–24
146	121	82.87	70	124	57	41	71.92	47−	"	Wavy	"	27–22
151	122	80.79	67	129	50	44	88.00	47−	"	Crinkly	"	24–21
135	115	85.18	59	122	47	41	87.23	47−	"	Frizzy	Br+2	29–27
141	123	87.23	72	123	57	44	77.19	47−	"	Wavy	Br+1	37–31
145	114	78.62	68	127	55	40	72.72	24	"	Crinkly	"	22–18
133	125	93.98	72	117	49	37	75.51	23	"	Straight	Br−1	35–26
144	124	86.11	71	124	52	41	78.84	47−	"	Wavy	Br+1	39–30
144	118	81.94	67	120	52	41	78.84	23	"	"	"	26–17
141	125	88.65	71	116	53	39	73.58	47	"	Frizzy	"	30–31
138	113	81.88	62	118	49	40	81.63	24	"	Straight	"	35–33
133	113	84.96	61	...	48	49	102.08	*17*	"	Wavy	"	32
138	120	86.96	67	...	54	48	88.89	*14*	"	Wavy	"	41
131	109	83.21	60	...	45	39	86.67	*16*	"	Curly	Brown	27
129.5	111	85.71	60	...	45	35	77.78	*16*	"	Wavy	"	25
130	109	83.85	65	...	51	40	78.43	*15*	"	"	Br+1	..
129	113	87.60	66	...	51	43	84.31	*15*	"	"	Brown	27
131	113	86.26	67	...	47	44	93.62	*17*	"	"	Br+1	24

TABLE I (continued)

Adult Females

Subject No.	Age	Bodily Measurements in Cm.								Head Measurements in Mm.			
		Weight lbs.	Stature	Height of Acromion	Height of Dactylion	Height Sitting	Arm Length	Index of Arm Length %	Index of Ht. Sitting %	Length	Breadth	Cephalic Index %	Min. Frontal Diam.
312	36	145	155.9	127.7	56.2	86.2	71.5	45.86	55.29	170	148	87.06	...
318	29	190	166.0	138.0	64.2	86.4	73.8	44.46	52.05	172	148	86.05	...
319	48	...	164.0	136.2	63.3	85.9	72.9	44.45	52.38	166	151	90.96	...
322	20	...	165.6	135.7	62.6	86.9	73.1	44.14	52.47	164	144	87.80	...
324	20	...	174.1	145.0	64.7	89.2	80.3	46.12	51.23	175	146	83.43	...
331	18	112	154.7	126.4	59.0	82.4	67.4	43.57	53.26	167	146	87.42	...
338	28	126	160.4	131.3	60.6	85.9	70.7	44.08	53.55	181	138	76.24	...
427	30	138	157.5	128.6	59.9	83.4	68.7	43.62	52.95	179	145	81.00	...
459	35	...	163.9	136.2	56.3	84.4	....	....	51.49	172	141	81.98	...
464	46	...	155.3	127.2	59.3	82.0	67.9	43.72	52.80	180	154	85.55	...

Immature Females

Subject No.	Age	Weight lbs.	Stature	Height of Acromion	Height of Dactylion	Height Sitting	Arm Length	Index of Arm Length %	Index of Ht. Sitting %	Length	Breadth	Cephalic Index %	Min. Frontal Diam.
20[9]	13	...	153.5	121.3	56.9	76.5	64.4	41.95	49.84	173	152	87.86	116
21[10]	7	...	124.0	97.8	44.0	61.2	53.8	43.39	49.35	169	140	82.84	111
94	17	...	162.7	132.2	58.7	84.9	73.5	45.17	52.18	186	149	80.11	118
97	14	...	157.1	125.4	54.8	80.6	70.6	44.50	51.30	186	146	78.49	112
113	9	...	128.5	102.6	46.4	62.3	56.2	43.73	48.48	172	146	84.88	105
114	8	...	132.9	107.9	49.4	69.5	58.5	44.02	52.29	173	149	86.13	108
178	13	...	147.1	118.5	51.4	74.4	67.1	45.61	50.58	175	142	81.14	103
195	13	...	135.7	108.0	47.2	72.4	60.8	44.80	53.35	174	149	85.63	112
199	17	...	171.3	139.4	61.3	88.0	78.1	45.59	51.37	182	152	83.52	120
200	15	...	154.1	123.8	56.2	81.0	67.6	43.87	52.56	168	143	85.12	112
201	15	...	151.5	123.3	55.8	80.4	67.5	44.55	53.07	165	143	86.67	110
206	17	...	156.4	126.5	56.7	82.0	69.8	44.62	52.43	177	158	89.27	116
208	15	...	163.4	133.2	58.9	87.4	74.3	45.47	53.49	178	149	83.71	115
210	17	...	154.8	123.8	54.9	84.4	68.9	44.51	54.52	175	153	87.43	113
212	16	...	151.6	122.7	53.8	82.9	68.9	45.45	54.68	179	144	80.45	118
216	16	...	153.2	122.2	55.1	79.8	67.1	43.80	52.09	177	144	81.36	114
218	15	...	150.2	120.7	50.8	82.1	69.9	46.54	54.66	180	156	86.67	117
220	17	...	163.3	135.2	62.8	86.9	72.4	44.33	53.21	182	152	83.52	111
224	17	...	161.5	130.1	57.3	84.7	72.8	45.08	52.45	170	140	82.35	112
229	17	...	159.0	128.7	57.3	85.0	71.4	44.90	53.46	171	154	90.06	107
235	16	...	162.1	132.8	60.9	88.3	71.9	44.60	54.47	178	152	85.39	117
236	16	...	151.5	120.9	53.8	81.9	67.1	44.29	54.06	177	156	88.14	110
237	16	...	152.0	121.8	52.9	80.3	68.9	45.33	52.83	171	148	86.55	110
240	16	...	152.5	123.8	54.3	79.3	69.5	45.57	52.00	171	152	88.89	112
241[11]	16	...	154.0	123.5	55.3	78.6	68.2	44.29	51.04	180	151	83.89	111
242	16	...	153.7	122.8	56.2	84.0	66.6	43.33	54.65	175	148	84.57	107

[9] Daughter of ♀ No. 19 (Hawaiian). [10] Daughter of ♀ No. 17. [11] Nos. 241 and 247 are sisters.

TABLE I (continued)

Adult Females

Face Measurements in Mm.								Descriptive				
Bizygomatic Diam.	Nasion Menton Ht.	Facial Index %	Nasion Prosthion Ht.	Bigonial Diam.	Nasal Ht.	Nasal Bth.	Nasal Index %	Skin Color	Hair Color	Hair Form	Eye Color	Strength rt. lft.
128	109	85.16	58	...	45	41	91.11	*14*	Br+1	Wavy	Br+1	32
138	108	78.26	64	...	50	38	76.00	*13*	Black	"	Brown	29
132	113	85.61	66	...	49	42	85.71	*14*	"	"	Br+1	27
129	114	88.37	65	...	51	38	74.51	*15*	Br+1	"	"	27
136	127	93.38	69	...	55	39	70.91	*12*	Black	Curly	"	33
124	101	81.45	59	...	44	38	86.36	*13*	"	Wavy	"	21
127	114	89.76	63	...	48	38	79.17	*11*	"	"	Brown	31
129	113	87.60	69	...	47	38	80.85	...	..	..	..	..
130	109	83.85	62	...	44	39	88.64	...	Black	Kinky	Brown	..
135	116	85.92	60	...	54	47	87.04	...	"	Wavy	Br+1	..

Immature Females

135	109	80.74	67	98	50	34	68.00	23	Black	Wavy	Brown	19–13
130	94	72.31	55	100	41	34	82.93	40−	"	Straight	"	10–9
139	120	86.33	71	115	53	40	75.47	47−	"	Wavy	"	25–23
133	124	93.23	74	109	54	40	74.07	24	"	Curly	"	22–25
128	108	84.38	68	101	48	37	77.08	47−	Br+2	Wavy	Br+2	7–7
133	110	82.71	67	107	54	36	66.67	47	Black	"	Br+1	14–10
125	113	90.40	65	113	50	37	74.00	47	Br+1	"	Brown	19–14
127	107	84.25	61	111	43	41	95.35	23+	Black	"	Br+1	18–12
...	...	....	...	...	60	38	63.33	47	"	"	"	44–37
140	118	84.29	68	119	54	38	70.37	23	"	"	Brown	26–23
141	113	80.14	70	123	50	34	68.00	47	"	Frizzy	Br+1	28–17
142	125	87.41	74	130	57	39	68.42	23−	Br+1	Curly	Brown	22–25
138	120	86.96	70	122	54	35	64.81	23	Black	Wavy	Br+1	39–35
136	118	86.76	70	122	50	41	82.00	47−	"	Curly	"	28–21
136	117	86.03	72	133	51	39	76.47	24	"	Wavy	Brown	22–20
136	113	83.09	64	123	49	43	87.76	24	"	"	Br+1	24–23
140	111	79.29	66	129	51	44	86.27	24	"	Straight	Brown	24–17
136	115	84.56	70	123	53	39	73.58	24	"	Wavy	"	31–28
139	113	81.29	64	128	49	39	79.59	24	"	Curly	"	30–31
136	107	78.68	60	123	49	37	75.51	24	Red Br	Wavy	Br−1	25–17
145	120	82.76	74	138	57	40	70.18	24	Black	"	Br+1	32–30
135	114	84.44	67	123	48	37	77.08	24	"	"	Brown	31–26
139	117	84.17	70	119	54	39	72.22	23	"	"	Br+1	21–19
138	117	84.78	68	124	54	41	75.93	47	"	Straight	Brown	24–20
141	119	84.40	72	127	56	43	76.79	24−	"	Wavy	Brown	29–27
133	116	87.21	72	118	54	35	64.81	24	"	"	Br−1	20–26

TABLE I (continued)

Immature Females

Subject No.	Age	Bodily Measurements in Cm.								Head Measurements in Mm.			
		Weight lbs.	Stature	Height of Acromion	Height of Dactylion	Height Sitting	Arm Length	Index of Arm Length %	Index of Ht. Sitting %	Length	Breadth	Cephalic Index %	Min. Frontal Diam.
243	16	...	153.0	125.1	55.5	84.9	69.6	45.49	55.49	173	153	88.44	107
246	16	...	157.5	125.8	53.4	81.8	72.4	45.97	51.94	180	155	86.11	111
247[11]	15	...	155.3	127.8	57.9	83.0	69.9	45.01	53.44	184	142	77.17	113
256	11	...	132.2	107.5	45.2	69.2	62.3	47.13	52.34	168	164	97.62	110
257	16	...	151.5	122.4	54.2	77.9	68.2	45.02	51.42	169	148	87.57	109
258	16	...	154.2	122.8	53.4	83.4	69.4	45.01	54.09	176	149	84.66	111
261	10	...	145.0	115.4	50.4	75.6	65.0	44.83	52.14	172	155	90.12	111
266	17	...	153.9	124.4	55.0	80.6	69.4	45.09	52.37	175	158	90.29	111
267	16	...	147.0	120.8	55.5	78.4	65.3	44.42	53.33	171	154	90.06	110
268	16	...	151.8	124.8	56.6	85.3	68.2	44.93	56.19	177	163	92.09	108
270	17	...	157.5	127.8	58.5	85.1	69.3	44.00	54.03	182	154	84.62	115
429	17	118	155.5	124.4	56.9	80.7	67.5	43.41	51.90	169	141	83.43	...

TABLE I (continued)

Immature Females

Face Measurements in Mm.								Descriptive				
Bizygomatic Diam.	Nasion Menton Ht.	Facial Index %	Nasion Prosthion Ht.	Bigonial Diam.	Nasal Ht.	Nasal Bth.	Nasal Index %	Skin Color	Hair Color	Hair Form	Eye Color	Strength
142	114	80.28	65	124	47	41	87.23	24	Black	Wavy	Brown	21–20
143	119	83.22	71	125	49	35	71.43	25	"	Curly	Brown	23–22
139	122	87.77	75	123	58	45	77.59	24	Br+1	Wavy	Brown	29–21
134	111	82.84	66	120	50	37	74.00	24	"	"	Br−1	22–17
137	107	78.10	66	119	49	37	75.51	24	Black	"	Br−1	20–20
139	118	84.89	72	118	55	39	70.91	23	"	"	Brown	31–28
137	112	81.75	66	121	49	38	77.55	23	Brown	Straight	"	20–15
140	113	80.71	66	122	49	42	85.71	24	Black	Wavy	"	29–20
145	115	79.31	64	133	49	41	83.67	23	"	Curly	"	26–24
143	117	81.82	68	130	51	40	78.43	24	"	Straight	Br−1	20–22
139	117	84.17	70	125	50	37	74.00	24	"	Wavy	Brown	34–27
127	...	85.83	58	...	42	35	88.10	...	....	....	....	...

TABLE II. PURE CHINESE

Subject No.	Age	Bodily Measurements in Cm. Weight lbs.	Stature	Height of Acromion	Height of Dactylion	Height Sitting	Arm Length	Index of Arm Length %	Index of Ht. Sitting %	Head Measurements in Mm. Length	Breadth	Cephalic Index %	Min. Frontal Diam.
Adult Males													
63	20	...	164.3	133.5	58.0	86.2	75.5	45.95	52.47	184	143	77.71	115
64	20	137	171.0	137.5	63.2	87.6	74.3	43.45	51.23	185	155	83.78	122
73	20	...	169.3	135.5	62.8	93.8	72.7	42.94	55.40	200	146	73.00	123
169	50	144	160.8	131.2	56.5	87.3	74.7	46.45	54.29	190	154	81.05	112
172	51	...	159.4	128.5	57.2	90.0	71.3	44.73	56.46	197	146	74.11	115
173	35	126	169.2	135.3	60.6	90.3	74.7	44.15	53.37	190	156	82.10	119
174	45	110	154.9	126.0	57.5	81.1	68.5	44.22	52.36	194	158	81.44	117
365	34	153	165.9	135.5	59.2	85.7	76.3	45.99	51.66	181	140	77.35	...
369	32	130	170.0	137.3	58.9	88.8	78.4	46.12	52.23	174	143	82.18	...
Immature Males													
1	16	...	162.0	133.0	60.0	83.7	73.0	45.06	51.67	178	158	88.76	120
3	12	...	127.0	101.0	46.6	65.7	54.4	42.83	51.73	169	145	85.80	119
70	19	...	167.4	136.5	59.8	87.0	76.7	45.82	51.97	192	152	79.16	121
72	15	...	154.0	134.0	54.9	80.5	79.1	51.36	52.27	182	152	83.51	112
74	18	110	163.4	132.3	57.4	82.3	74.9	45.84	50.37	179	153	85.47	123
126	16	101	160.1	132.0	63.5	88.4	68.5	42.79	55.21	195	144	73.84	116
Adult Females													
170	39	118	153.6	125.3	54.9	80.8	70.4	45.83	52.60	176	146	82.95	119
295	22	103	151.4	124.1	59.4	81.8	64.7	42.73	54.03	165	138	83.64	...
332	22	94	160.0	134.0	63.3	84.9	70.7	44.19	53.06	164	133	81.10	...
Immature Females													
118	16	100	157.9	126.1	57.9	86.5	68.2	43.19	54.78	186	143	76.88	115
122	18	...	160.2	131.5	60.2	86.9	71.3	44.51	54.24	178	149	83.70	112

TABLE II. PURE CHINESE

Adult Males

Face Measurements in Mm.								Descriptive					
Bizygomatic Diam.	Nasion Menton Ht.	Facial Index %	Nasion Prosthion Ht.	Bigonial Diam.	Nasal Ht.	Nasal Bth.	Nasal Index %	Skin Color	Hair Color	Hair Form	Eye Color	Strength	Eye Fold[1]
132	128	96.96	80	110	56	41	73.21	47	Black	Straight	Brown	36–37	0
144	123	85.41	76	118	55	40	72.73	47	"	"	Br+1	48–48	0
141	130	92.19	74	115	55	40	72.73	23	"	"	Brown	58–60	+
146	123	84.24	71	134	55	45	81.82	24—	"	"	"	41–37	—
136	116	85.29	64	116	52	43	82.69	24	"	"	Br—1	34–20	0
144	135	93.75	74	122	52	42	80.77	23	"	"	Brown	40–39	—
138	125	90.57	71	123	51	44	86.27	23—	"	"	Br—1	38–41	+
131	120	91.60	72	. . .	49	38	77.55	. .	"	"	Brown	54	+
136	118	86.76	66	. . .	45	41	91.11	. .	"	"	"	32	0
Immature Males													
141	120	85.11	70	120	54	40	74.07	. .	"	"	Black	44–31	0
130	113	86.92	68	114	47	36	76.59	. .	"	"	"	9–8	0
149	119	79.86	72	114	53	39	73.58	23	"	"	Brown	58–48	+
110	110	100.00	70	112	55	39	70.91	47—	"	"	Br+1	24–25	0
141	121	85.81	71	121	54	39	72.22	23	"	"	Brown	47–45	+
126	125	99.20	72	113	53	42	79.24	24	"	"	Br+2	43–28	+
Adult Females													
135	114	84.44	67	127	52	41	78.85	23	"	"	Brown	30–25	+
125.5	102	81.27	62	. . .	40	36	90.00	. .	Br+1	"	. . . .	27	+
127	100	78.74	59	. . .	45	34	75.55	. .	Black	"	Br+1	27	0
Immature Females													
135	118	87.40	69	107	47	34	72.34	23	"	"	Br+1	23–20	±
137	117	85.40	70	116	51	34	66.67	23	"	"	Brown	25–21	+

[1] In describing the eye fold the following abbreviations are used: + present; — absent; 0 no record; ± slight.

TABLE III. F_1 HAWAIIAN × CHINESE

Hybrids between Hawaiian and South Chinese

Adult Males

Subject No.	Age	Bodily Measurements in Cm.								Head Measurements in Mm.			
		Weight lbs.	Stature	Height of Acromion	Height of Dactylion	Height Sitting	Arm Length	Index of Arm Length %	Index of Ht. Sitting %	Length	Breadth	Cephalic Index %	Min. Frontal Diam.
184	21	123	157.8	129.2	55.9	82.3	73.3	46.45	52.15	183	151	82.51	111
370	48	171	176.2	144.5	67.3	93.5	77.2	43.81	53.06	165	154	93.33	...
378	22	110	157.1	126.7	60.0	86.5	66.7	42.46	55.06	176	141	80.11	...
411	48	167	171.5	139.4	64.5	92.2	74.9	43.67	53.76	176	155	88.07	...
Immature Males													
22	15	...	166.7	136.0	62.0	82.2	74.0	44.39	49.31	183	158	86.33	117
28	15	...	157.5	127.5	56.0	79.4	71.5	45.40	50.41	166	156	93.97	116
31[1]	19	...	169.0	137.5	66.3	91.5	71.2	42.13	54.14	188	162	86.17	127
56	17	...	165.0	135.9	61.8	85.3	74.1	44.91	51.70	176	157	89.20	125
75	17	...	160.4	130.5	58.5	80.7	72.0	44.89	50.31	170	153	90.00	113
155	16	126	158.8	129.0	62.3	86.2	66.7	42.00	54.28	177	152	85.87	119
166	19	162	176.8	143.5	61.8	91.6	81.7	46.27	51.81	200	155	77.50	121
354	19	132	160.7	132.6	60.6	86.9	72.0	44.80	54.07	171	148	86.55	...
471	17	112	153.6	124.6	54.8	81.7	69.8	45.44	53.19	174	138	79.31	...
485	17	105	165.1	135.5	64.2	84.0	71.3	43.19	50.87	165	144	87.27	...
Adult Females													
5[2]	40	...	161.0	132.0	61.8	84.5	70.2	43.60	52.48	175	152	86.85	120
88	18	...	157.8	125.2	54.3	83.8	70.9	44.93	53.10	173	153	88.43	114
120	21	114	160.8	131.9	62.6	86.5	69.3	43.1	53.79	182	148	81.31	107
196	18	...	161.6	129.5	59.2	84.7	70.3	43.5	52.41	173	152	87.86	118
292	19	110	160.7	131.0	61.3	84.9	69.7	43.37	52.83	163	133	81.59	...
300	39	115	155.4	126.9	61.5	89.9	65.4	42.08	57.85	162	145	89.51	...
320	23	96	148.0	121.2	57.3	81.5	63.9	43.17	55.07	157	136	86.62	...
327	24	154	168.7	138.0	62.2	90.4	75.8	44.93	53.59	169	149	88.16	...
340	32	102	150.3	124.3	56.7	82.0	67.6	44.98	54.56	162	145	89.51	...
452	28	122	157.7	128.9	...	85.6	...	49.52	54.28	172	137	79.65	...
502	35	139	150.9	120.6	55.8	79.0	64.8	42.94	52.35	164	142	86.58	...
Immature Females													
262	14	...	149.6	121.2	54.3	78.5	66.9	44.72	52.47	179	146	81.56	109
443	17	134	151.2	121.3	54.5	84.1	66.8	44.18	55.62	165	136	82.42	...
435	17	100	154.5	124.8	54.3	82.3	70.5	45.63	53.27	161	140	86.95	...

[1] Brother of No. 28.

[2] Wife of No. 4 (Hawaiian), mother of Nos. 6–15 (Backcross F_1 × Hawaiian).

TABLE III. F_1 HAWAIIAN × CHINESE

Hybrids between Hawaiian and South Chinese

Face Measurements in Mm.								Descriptive					
Bizygomatic Diam.	Nasion Menton Ht.	Facial Index %	Nasion Prosthion Ht.	Bigonial Diam.	Nasal Ht.	Nasal Bth.	Nasal Index %	Skin Color	Hair Color	Hair Form	Eye Color	Strength	Eye Fold
Adult Males													
139	117	84.17	70	119	52	43	82.69	..	Black	Wavy	Brown	36–29	—
143	116	81.12	66	...	54	36	66.67	*9*	"	"	Br−1	39	±
130	111	85.38	63	...	48	38	79.17	..	"	Straight	Brown	41	0
136	119	87.50	72	...	53	40	75.47	..	"	Curly	"	..	0
Immature Males													
143	116	81.11	81	112	58	45	77.59	40	"	Straight	Brown	35–32	0
138	118	85.50	69	115	53	37	69.81	23	"	Sl wavy	"	45–38	0
146	138	94.52	87	111	58	38	65.52	23	"	"	"	51–44	0
149	119	79.86	70	119	53	42	79.24	47	"	Wavy	Br+1	40–41	—
138	119	86.23	71	108	49	37	75.51	23	"	Straight	Brown	29–28	0
144	113	78.47	68	120	49	37	75.51	23	"	Sl wavy	Br+1	32–28	±
148	126	85.13	73	128	52	41	78.85	..	Br+1	Straight	Brown	54–47	+
129	109	84.50	65	...	50	40	80.00	..	Black	"	Br+1	50	+
128	101	78.91	61	...	44	38	86.36	..	"	"	"	49	+
128	107	83.59	56	...	43	37	86.05	..	Br+1	"	Brown	..	+
Adult Females													
138	109	78.98	63	113	49	36	73.47	47	Black	"	Brown	22–20	—
136	111	81.60	68	115	51	42	82.35	47	"	"	Br+1	26–25	±
134	115	85.82	68	117	49	39	79.59	24	"	"	Brown	28–23	±
144	115	79.86	67	128	51	36	70.59	24	"	Wavy	Br+1	1–9	—
124	101	81.45	62	...	43	36	83.72	*15*	"	Wiry	Brown	29	0
126	99	78.57	63	...	49	39	79.59	*8*	"	Straight	Br+1	20	0
124	102	82.26	62	...	45	36	80.60	*15*	"	"	"	26	0
136	117	86.03	65	...	50	40	80.00	*14*	"	"	"	43	+
127	107	84.25	62	...	43	40	93.02	*10*	"	"	Brown	20	0
127	117	92.12	65	...	46	36	78.26	..	"	"	Br+1	..	+
127	109	85.83	68	...	47	37	78.72	..	"	"	Brown	..	±
Immature Females													
132	106	80.30	61	116	45	43	95.55	24	"	Wavy	Brown	23–20	0
123	107	86.99	56	...	39	39	100.00	..	"	Straight	Br+1	..	0
126	109	86.51	67	...	46	37	80.43	..	"	Wavy	....	..	0

TABLE III (continued)

F₂ HAWAIIAN × CHINESE

Adult Females

Subject No.	Age	Bodily Measurements in Cm.: Weight lbs.	Stature	Height of Acromion	Height of Dactylion	Height Sitting	Arm Length	Index of Arm Length %	Index of Ht. Sitting %	Head Measurements in Mm.: Length	Breadth	Cephalic Index %	Min. Frontal Diam.
61	21	120	158.4	126.8	62.3	83.2	64.5	40.72	52.53	175	139	79.43	107
315	38	168	159.9	130.2	61.7	86.2	68.5	42.84	53.91	171	148	86.55	...
446	18	123	159.7	131.2	60.7	83.0	70.5	44.15	51.97	171	141	82.46	...
Immature Females													
160	17	...	165.4	135.3	63.6	86.3	71.7	43.35	52.18	184	150	81.52	116
250	16	...	158.0	127.5	57.3	86.2	70.2	44.43	54.56	178	155	87.08	114
479	15	...	149.0	121.0	55.5	76.9	65.5	43.96	51.61	170	138	81.18	...
BACKCROSS F₁ × HAWAIIAN — *Adult Males*													
15[3]	25	175	173.0	141.0	63.2	85.3	77.8	44.97	49.31	178	163	91.57	137
193	adult	175	163.0	133.5	59.3	86.6	74.2	45.52	53.13	186	147	79.03	118
383	19	163	166.8	135.0	58.9	85.9	76.1	45.62	51.50	195	147	75.38	...
Adult Females													
7[3]	23	...	160.7	128.5	57.8	85.9	70.7	43.99	53.45	178	151	84.83	127
10[3]	19	...	153.0	122.5	55.0	83.0	67.5	44.12	54.25	183	140	76.50	116
297	23	128	160.5	130.4	60.0	84.3	70.4	43.86	52.52	175	151	86.29	...
326	20	149	167.4	137.4	59.3	88.9	78.1	46.65	53.11	170	141	82.94	...
339	20	129	153.6	125.4	58.0	83.9	67.4	43.88	54.62	159	135	84.91	...
453	23	145	153.9	125.8	58.8	82.6	67.0	43.53	53.67	165	142	86.06	...
Immature Males													
6[3]	16	...	111.5	139.8	63.5	89.5	76.3	44.49	52.19	195	149	76.41	125
8[3]	13	...	141.4	112.0	49.9	75.5	62.1	43.92	53.39	195	145	74.36	122
42	15	...	165.0	132.0	59.0	85.0	73.0	44.24	51.51	178	158	88.76	117
191	8	...	115.5	90.5	42.1	64.5	48.4	41.90	55.84	161	145	90.06	100
461	15	100	152.4	124.8	54.7	77.3	70.1	46.00	50.72	171	146	85.38	...
472	16	102	160.9	130.8	58.2	82.9	72.6	45.12	51.52	176	136	77.27	...
466	16	132	172.2	139.4	61.8	87.0	77.6	45.06	50.52	172	138	80.23	...
469	17	121	156.5	128.5	55.8	81.7	72.7	46.45	52.20	161	138	85.71	...

[3] Children of ♀ No. 5 (F₁ Hawaiian × Chinese) × ♂ No. 4 (Hawaiian).

TABLE III (continued)

F₂ HAWAIIAN × CHINESE

Adult Females

Face Measurements in Mm.								Descriptive					
Bizygomatic Diam.	Nasion Menton Ht.	Facial Index %	Nasion Prosthion Ht.	Bigonial Diam.	Nasal Ht.	Nasal Bth.	Nasal Index %	Skin Color	Hair Color	Hair Form	Eye Color	Strength	Eye Fold
130	109	83.85	70	104	51	35	68.63	23	Black	Straight	Br+1	26–19	—
131	111	84.73	66	...	51	42	82.35	*13*	"	"	"	20	0
125	110	88.00	63	...	47	37	78.72	..	"	"	"	..	0
Immature Females													
135	113	83.70	68	105	48	34	70.83	23—	Brown	Wavy	Br—1	28–23	—
144	122	84.72	75	126	57	45	78.95	23	Black	"	Brown	32–28	+
119	101	84.87	57	...	39	36	92.31	..	"	"	Br+1	..	+

BACKCROSS F_1 × HAWAIIAN

Adult Males

154	116	75.32	69	117	55	43	78.18	23	"	Curly	"	60–43	—
147	126	85.71	73	132	52	43	82.69	..	"	Wavy	Brown	48–36	±
142	124	87.32	67	...	52	46	88.46	..	"	Curly	Br+1	45	+
Adult Females													
143	111	77.62	68	104	51	40	78.43	40—	"	"	Brown	25–20	—
139	106	76.26	61	107	46	40	86.96	40—	"	"	Br+1	22–23	—
135	109	80.74	64	...	52	41	78.85	*13*	"	Straight	Brown	20	+
130	112	86.15	66	...	47	39	82.98	*15*	"	Wavy	Br+1	29	0
126	103	81.75	61	...	42	38	90.48	*12*	"	Straight	"	25	+
130	116	89.23	63	...	50	42	84.00	..	"	Wavy	"	..	+
Immature Males													
142	118	83.11	71	...	53	40	75.47	46—	Black	Curly	Brown	50–49	—
139	107	76.98	62	...	45	44	97.78	40	"	Straight	Br+1	21–18	—
140	113	80.71	68	...	57	40	70.17	39	"	Wavy	Br+2	..	+
125	100	80.00	65	...	38	33	86.84	..	"	"	Br+1	9–9	—
127	116	91.34	71	...	50	41	82.00	..	"	Curly	"	..	+
126	106	84.13	64	...	45	38	84.44	..	"	Wavy	Brown	38	+
129	114	88.37	69	...	47	36	76.59	..	"	Straight	Br+1	..	+
129	109	84.50	62	...	47	41	87.23	..	"	"	"	..	+

TABLE III (continued)

Immature Females

Subject No.	Age	Bodily Measurements in Cm. Weight lbs.	Stature	Height of Acromion	Height of Dactylion	Height Sitting	Arm Length	Index of Arm Length %	Index of Ht. Sitting %	Head Measurements in Mm. Length	Breadth	Cephalic Index %	Min. Frontal Diam.
11[3]	9	...	131.5	103.0	44.3	70.3	58.7	44.64	53.46	190	135	71.05	106
12[3]	5	...	107.5	83.5	33.8	58.2	49.7	46.23	54.14	176	137	77.84	101
13[3]	10	...	130.5	104.0	46.0	71.3	58.0	44.44	54.64	167	148	88.62	114
95	14	...	156.0	128.5	59.6	83.6	68.9	44.17	53.59	167	146	87.43	116
225	17	...	152.9	121.8	52.4	78.5	69.4	45.39	51.34	170	149	87.65	111
227	17	...	155.4	125.5	57.3	84.8	68.2	43.89	54.57	190	148	77.89	106
239	17	...	161.6	131.2	61.7	87.3	69.5	43.01	54.02	171	153	89.47	112
245	16	...	159.6	128.8	57.7	87.0	71.1	44.55	54.51	174	164	94.25	113
251	15	...	153.6	124.8	54.3	81.2	70.5	45.90	52.86	173	142	82.08	103
259	17	...	150.0	122.0	52.8	80.5	69.2	46.13	53.67	171	145	84.80	112
271	13	...	148.5	121.4	51.0	76.0	70.4	47.41	51.18	182	143	78.57	113

BACKCROSS F_1 × CHINESE

Males

80	15	...	145.4	117.9	49.9	74.6	68.0	46.77	51.31	178	148	83.15	117
376	29	150	170.9	140.2	64.0	91.0	76.2	44.59	53.25	173	153	88.44	...

Females

264	16	...	155.2	125.7	56.1	84.1	69.6	44.85	54.19	175	148	84.57	112
428	16	90	147.3	119.2	57.0	76.9	62.2	42.23	52.21	166	132	79.52	...
455	16	...	151.2	123.1	55.4	76.4	67.7	44.77	50.51	164	139	84.76	...

OTHER HAWAIIAN-CHINESE MIXTURES[4]

Males

395	34	136	172.8	141.0	65.1	92.5	75.9	43.92	53.53	171	146	85.38	...
353	18	135	168.0	138.2	59.9	85.6	78.3	46.61	50.95	174	134	77.01	...

Females

269	14	...	158.0	128.9	57.8	82.8	71.1	45.00	52.41	181	146	80.66	116
335	18	138	173.3	142.3	67.8	88.7	74.5	42.99	51.18	171	141	82.46	...
440	18	110	156.9	127.3	56.6	84.1	70.7	45.06	53.60	172	139	80.81	...
474	16	121	160.5	130.3	59.1	83.3	69.3	43.18	51.90	180	137	76.11	...
488	18	135	165.4	133.6	58.0	86.9	75.6	45.71	52.54	180	143	79.44	...
500	17	...	158.0	128.2	58.9	81.4	69.3	43.86	51.52	169	144	85.21	...

[4] Ancestry doubtful; probably ⅛ to ¼ Chinese.

TABLE III (continued)

Immature Females

Face Measurements in Mm.								Descriptive					
Bizygo-matic Diam.	Nasion Men-ton Ht.	Facial Index %	Nasion Pros-thion Ht.	Bigo-nial Diam.	Nasal Ht.	Nasal Bth.	Nasal Index %	Skin Color	Hair Color	Hair Form	Eye Color	Strength	Eye Fold
123	101	82.11	64	91	47	35	74.47	40	Black	Kinky	Br+1	14–12	–
127	98	77.17	57	103	41	34	82.93	23	"	Straight	Br+2	9–7	–
137	100	72.99	61	106	46	38	82.61	23	"	"	Brown	10–9	–
138	107	77.54	66	108	55	37	67.27	47–	"	Wavy	"	23–20	+
139	114	82.01	66	125	51	40	78.43	23	"	"	"	22–19	–
142	114	80.29	69	124	53	40	75.47	23–	Red br	"	Br–1	30–32	0
142	111	78.17	70	127	53	39	73.59	24	Black	Straight	Brown	30–27	–
142	120	84.51	73	124	55	38	69.09	24	Br+1	Curly	"	28–25	±
129	113	87.60	73	116	52	38	73.08	24	Black	Wavy	"	17–16	±
138	113	81.88	69	125	45	37	82.22	23	Br+1	"	Br–1	19–13	+
133	117	87.97	72	127	51	41	80.39	23	"	Straight	Brown	26–23	+

BACKCROSS F_1 × CHINESE

Males

140	116	82.86	69	112	53	38	71.70	39–	Black	Wavy	"	33–34	–
141	112	79.43	69	...	53	43	81.13	...	"	Curly	Br+1	48	–

Females

142	109	76.76	65	128	48	36	75.00	24	"	Straight	Br+1	31–25	+
122	115	94.26	60	...	43	38	88.37	..	....	....	....	..	+
122	107	87.70	58	...	41	36	87.80	..	Black	Straight	Br+1	..	+

OTHER HAWAIIAN–CHINESE MIXTURES [4]

Males

131	118	90.08	68	...	52	36	69.23	..	"	"	Brown	56	+
127	125	98.43	79	...	53	44	83.02	..	"	Wavy	"	42	+

Females

141	112	79.43	65	122	46	41	89.13	24	"	Straight	"	29–23	+
129	107	82.95	61	...	47	42	89.36	..	"	"	Br+1	..	+
125	105	84.00	61	...	40	39	97.50	..	"	Wavy	Br+1	..	+
121	111	91.73	66	...	46	39	84.78	..	"	Straight	Br+1	..	+
128	113	88.28	67	...	47	37	78.72	..	....	"	Br+1	..	+
120	105	87.50	60	...	45	35	77.78	..	Black	"	"	..	+

TABLE IV. HAWAIIAN WHITE HYBRIDS

Adult F_1 Males

Subject No.	Age	Pedigree	Weight lbs.	Bodily Measurements in Cm. Stature	Height of Acromion	Height of Dactylion	Height Sitting	Arm Length	Index of Arm Length %	Index of Height Sitting %	Head Measurements in Mm. Length	Breadth	Cephalic Index %	Min. Frontal Diameter
128[1]	47	H/G	260	176.8	143.7	64.2	94.0	79.5	44.97	53.17	206	167	81.07	127
144	25	H/Sc	197	179.0	148.4	65.3	93.2	83.1	46.42	52.07	198	160	80.81	124
145	35	H/Sc	...	161.6	133.0	58.9	83.1	74.1	45.85	51.42	182	165	90.66	113
149	30	H/G	215	177.8	146.0	67.9	94.5	78.1	43.93	53.15	196	159	81.12	123
367	42	H/Am	170	171.3	140.7	65.1	92.9	75.6	44.13	54.23	177	159	89.83	...
400	19	H/Ca	132	166.3	136.5	61.2	84.1	75.3	45.27	50.57	184	138	75.00	...
403	65	H/Sc	170	174.2	144.8	65.8	90.7	79.0	45.35	52.07	184	148	80.43	...
408	55	H/Am	230	171.4	141.0	62.4	89.1	78.6	45.85	51.98	195	166	85.13	...
417	51	H/Am	191	181.4	150.1	65.5	92.6	84.6	46.64	51.05	182	148	81.32	...
418	64	H/W	180	175.0	141.9	62.2	92.7	79.7	45.54	52.97	184	156	84.78	...
347	21	H/P	160	163.2	134.7	61.9	87.9	72.8	44.60	53.86	180	147	81.67	...
364	29	H/Sp	165	165.7	135.7	60.0	87.8	75.7	45.68	52.98	177	151	85.31	...
391	50	H/P	160	170.2	137.2	56.6	88.4	80.6	47.35	51.94	188	154	81.91	...
493	20	H/P	135	165.4	135.3	60.0	87.3	75.3	45.53	52.78	177	150	84.75	...
				F_1 Females										
86	23	H/Am	116	165.8	135.8	65.2	88.9	70.6	42.58	52.98	183	156	85.25	109
232[2]	35	H/Ir	...	156.6	129.4	63.8	86.4	65.6	41.89	55.17	189	153	80.95	113
296	50	H/E	180	166.9	139.4	65.8	89.0	73.6	44.09	53.33	167	146	87.43	...
328	18	H/Sw	135	167.4	138.4	65.0	86.6	73.4	43.84	51.73	164	140	85.37	...
439	18	H/Am	...	156.2	127.2	59.7	86.4	67.5	43.21	55.31	165	142	86.06	...
310	24	H/Am-I	154	161.8	132.7	63.3	85.5	69.4	42.89	52.84	170	144	84.71	...
285[3]	73	H/E	140	164.0	135.5	...	88.7	...	....	54.09	180	146	81.11	...
				F_1 Males Immature										
48	14	H/G	...	166.	133.0	55.5	85.0	77.5	46.68	51.20	188	155	82.45	113
486	15	No/H	115	156.9	127.0	55.3	81.2	71.7	45.70	51.75	172	136	79.09	...
382	17	H/P	140	168.0	136.1	59.4	89.2	76.7	45.65	53.09	170	147	86.47	...
				F_1 Females Immature										
98	12	H/G	...	156.6	125.3	57.7	78.8	67.6	43.16	50.32	178	149	83.71	113
221[4]	16	H/W	...	157.5	126.2	57.2	85.0	69.0	43.87	53.97	181	151	83.43	116
228	17	H/G	...	163.6	132.7	61.7	86.5	71.0	43.39	52.87	171	145	84.80	108
263	16	H/Ir	...	152.5	123.3	54.8	84.2	68.5	44.92	55.21	169	149	88.17	107
265	17	H/Am	...	158.5	129.4	57.1	81.5	72.3	45.61	51.42	179	147	82.12	107

[1] Husband of No. 232 (F_1); father of Nos. 129–134 and 233 (F_2).
[2] Wife of No. 128 (F_1); mother of Nos. 129–134 and 233 (F_2).
[3] Old-measurements not included in averages.
[4] Mother a "Red Hawaiian" (Ehu).

TABLE IV. HAWAIIAN WHITE HYBRIDS

Adult F_1 Males

Facial Measurements in Mm.								Descriptive				
Bizygomatic Diameter	Nasion Menton Height	Facial Index %	Nasion Prosthion Height	Bigonial Diameter	Nose Height	Nose Breadth	Nasal Index %	Skin Color	Hair Color	Hair Form	Eye Color	Strength
165	137	83.03	76	150	52	45	66.54	23−	Black	Wavy	Br−1	74–68
155	125	80.65	70	130	53	41	77.36	23−	"	Curly	"	50–48
148	121	81.76	70	134	57	44	77.19	24	"	Wavy	Br	33–25
150	129	86.00	67	128	49	42	85.71	23	"	Curly	Hazel	77–85
139	123	88.49	68	...	50	49	98.00	...	"	Wavy	Br−1	47
127	112	88.19	65	...	46	43	93.48	...	Br+1	Curly	Br	52
137	130	94.89	75	...	58	43	74.14	*10*	Br	Wavy	Br−1	..
152	120	78.95	71	...	56	40	71.43	...	Br+1	"	Br	..
137	126	91.97	75	...	56	41	73.21	...	"	"	Blue	..
144	128	88.89	73	...	61	43	70.49	...	Black	"	Br−1	..
129	109	84.50	61	...	49	38	77.55	*16*	Br+1	Straight	Br	60
136	118	86.76	75	...	53	36	67.92	...	Black	Wavy	"	38
136	116	85.29	73	...	55	46	83.64	...	"	Curly	Br+1	46
134	113	84.33	63	...	46	41	89.13	...	Br+1	Wavy	Br	46
F_1 Females												
139	115	82.73	69	113	56	35	62.50	23	Br+1	Wavy	Br	29–29
152	122	80.26	67	134	54	41	75.92	23	Black	Frizzy	Br−1	28–25
130	126	96.92	73	...	56	35	62.50	*7*	"	Straight	Br	27
129	110	85.27	68	...	50	33	66.00	*14*	Br	Wavy	Br+1	42
127	110	86.61	63	...	46	34	73.91	...	"	"	Br	..
129	111	86.05	64	...	47	35	74.47	*8*	Br+1	"	Br	24
125	109	84.50	62	...	49	39	79.59	*9*	Black	"	Br−1	..
F_1 Males Immature												
144	120	83.33	73	113	55	39	70.91	23−	Br	Wavy	Br+1	32–28
121	104	85.95	62	...	45	35	77.78	...	"	Straight	Br−1	31
125	112	89.60	63	...	49	38	77.55	...	Black	"	Br+1	58
F_1 Females Immature												
131	117	89.31	72	114	53	37	69.81	24	Black	Wavy	Br−1	23–23
142	109	76.76	64	120	47	37	78.72	...	Red Br	—	Br−2	27–23
134	114	85.07	67	121	52	36	69.23	...	Br+2	Wavy	Br	32–28
135	102	75.56	61	115	43	32	74.42	23	Br + 1	"	Br	28–24
133	114	85.71	67	107	53	36	67.92	23	Black	Curly	Br	26–21

TABLE IV (continued).

F_1 Females Immature

Subject No.	Age	Pedigree	Weight lbs.	Bodily Measurements in Cm. Stature	Height of Acromion	Height of Dactylion	Height Sitting	Arm Length	Index of Arm Length %	Index of Height Sitting %	Head Measurements in Mm. Length	Breadth	Cephalic Index %	Min. Frontal Diameter
255	12	H/G	...	140.3	110.8	48.9	70.5	61.9	44.12	50.25	175	140	80.00	114
456	17	H/E	...	155.2	125.4	57.8	82.2	67.6	43.56	53.31	170	137	80.59	...
491	17	H/Ir	...	160.4	131.4	58.8	84.6	72.6	45.26	53.07	176	142	80.68	...
156	16	H/P	...	150.8	122.2	55.3	...	66.9	44.36	....	175	155	88.57	118
444	17	H/P	98	154.9	126.3	58.8	82.7	67.5	43.58	53.39	170	141	82.94	...
487	16	H/P	98	150.4	123.4	58.8	80.5	64.6	42.95	53.52	162	147	90.74	...
438	14	H/Je Am	...	141.2	112.9	50.1	74.2	62.8	44.47	52.55	170	136	80.00	...
							F_2 Adult Males							
276	ad	HW/HW	150	166.9	132.5	59	87.7	73.5	44.03	52.55	168	144	85.71	...
337	29	HW/HW	154	168.9	135.8	62.5	90.0	73.3	43.39	53.29	184	152	82.61	...
425	32	HW/HW	187	167.9	140.0	63.1	86.2	76.9	45.80	51.34	190	146	76.84	...
							F_2 Adult Females							
280	36	HW/HW	193	173.5	143.4	65.2	92.5	78.2	45.07	53.31	170	147	86.47	...
302	30	HAm/HAm	...	....	128.9	63.8	82.7	65.1	....	....	169	137	81.07	...
303	25	HG/HE	185	161.1	133.4	60.4	85.0	73.0	45.31	52.76	175	153	87.43	...
305	18	HAmHIr	125	158.5	130.7	64.5	82.4	66.2	41.76	51.99	166	133	80.12	...
489	18	HG/HP	138	169.9	140.9	63.6	86.7	77.3	45.50	51.03	173	130	75.14	...
							F_2 Males Immature							
165	13	HAm/HAm	85	149.2	120.0	52.5	72.6	67.5	45.24	48.66	196	142	72.45	109
179	18	HW/HW	142	171.2	138.6	63.2	89.8	75.4	44.04	52.45	193	155	80.31	120
23	17	HW/HW	...	159.7	127.5	57.3	83.9	70.2	43.95	52.54	188	157	83.51	119
26	17	"	...	172.1	139.2	62.0	86.0	77.2	44.85	49.97	182	161	88.46	125
467	16	HAm/HAm	90	161.5	134.8	62.0	82.0	72.8	45.07	50.77	178	139	78.09	...
484	18	HW/HW	120	155.4	125.3	54.9	83.1	70.4	45.30	53.47	177	139	78.53	...
							F_2 Females Immature							
96	16	HW/HW	...	160	129.8	58.3	86.4	71.5	44.68	54.00	184	147	79.89	115
214	17	"	...	169.3	132.0	58.8	85.3	73.2	43.23	50.38	182	156	85.71	111
222	16	"	...	154.1	123.8	57.0	84.2	66.8	43.34	54.64	185	143	77.30	106
252	15	"	...	158.3	126.5	57.5	84.2	69.0	43.59	53.19	185	144	77.84	107
433	16	HFr/HE	105	158.2	131.8	61.7	81.2	70.1	44.31	51.65	176	129	73.30	...
496	17	HW/HW	...	160.2	133.3	60.2	81.0	73.1	45.63	50.56	183	141	77.05	...
465	17	HP/HAm	111	164.0	133.4	61.0	84.1	72.4	44.15	51.28	164	134	81.71	...

TABLE IV (continued).

Facial Measurements in Mm.								Descriptive				
Bizygomatic Diameter	Nasion Menton Height	Facial Index %	Nasion Prosthion Height	Bigonial Diameter	Nose Height	Nose Breadth	Nasal Index %	Skin Color	Hair Color	Hair Form	Eye Color	Strength
F_1 Females Immature												
123	107	86.99	67	108	49	34	69.39	23	Br+1	Straight	Br	13–16
126	112	88.89	65	...	45	38	84.44	...	Br+2	Wavy	Br	....
130	106	81.54	59	...	41	36	87.80	...	Black	"	"	....
141	110	78.01	62	123	44	39	78.01	24	Black	Curly	Br	25–22
126	108	85.71	60	...	41	36	87.80	...	Br+1	Wavy	Br+1	....
127	103	81.10	55	...	45	33	73.33	...	Br+1	Curly	Blue	....
118	100	84.75	56	...	39	39	100.00	...	Br+1	Wavy	Br+1	....
F_2 Adult Males												
129	112	86.82	68	...	49	36	73.47	*12*	...	Wavy	Br−2	....
131	117	89.31	68	...	48	35	72.92	*12*	Black	"	Br	57
136	127	93.38	66	...	57	44	77.19	...	"	"	Br+1	....
F_2 Adult Females												
129	111	86.05	62	...	48	40	83.33	10	Br+1	Wavy	Br	32
118	106	89.83	63	...	45	31	68.89	12	Br	Straight	Br−2	25
125	119	95.20	73	...	46	39	84.78	11	Br+1	Wavy	...	30
122	109	89.34	62	...	47	33	70.21	10	Br+1	"	Br−1	22
121	109	90.08	62	...	47	35	74.47	...	Br+1	Curly	Br−1	....
F_2 Males Immature												
130	113	86.92	73	110	47	36	76.60	...	Br+1	Straight	Hazel	22–21
142	122	85.92	69	123	49	42	85.71	24	Black	Wavy	Br	48–36
141	118	83.69	72	119	55	37	67.27	40−	Black	"	Br+1	48–36
146	130	89.04	80	118	60	40	66.67	40	"	"	Br	44–40
123	107	86.00	60	...	41	37	90.24	...	Br+2	"	"	....
126	111	88.10	61	...	49	39	79.59	...	Black	"	Br+1	35
F_2 Females Immature												
143	112	78.32	59	118	48	37	77.08	23	Black	Wavy	Br+1	27–25
136	123	90.44	71	126	54	37	68.52	23−	Br+1	"	Blue	25–20
140	115	82.14	65	121	46	34	73.91	24	Black	"	Br	28–28
135	113	83.70	68	117	50	37	74.00	24	"	"	Br−1	28–26
115	105	91.30	62	...	44	32	72.73	...	Br+1	...	Lt Blue	....
124	114	91.94	65	...	50	34	68.00	...	Br+1	Wavy	Br	....
122	108	88.52	64	...	45	32	71.11	...	Br−1	Curly	Lt Blue	....

TABLE IV (continued)

F_2 Family — Children of F_1 no. 128 and F_1 no. 232

Subject No.	Age	Pedigree	Weight lbs.	Bodily Measurements in Cm. Stature	Height of Acromion	Height of Dactylion	Height Sitting	Arm Length	Index of Arm Length %	Index of Height Sitting %	Head Measurements in Mm. Length	Breadth	Cephalic Index %	Minimum Frontal Diameter
129	♂ 3	HIr/HG	...	98.2	76.7	33.0	57.4	43.7	44.51	58.45	173	143	82.66	99
130	♂ 7	"	...	128.3	96.3	43.4	65.1	52.9	41.23	50.74	182	145	79.67	112
131	♀ 14	"	...	155.9	127.5	60.0	85.3	67.5	43.30	54.71	185	150	81.08	122
132	♂ 13	"	...	154.1	126.8	57.9	80.4	68.9	44.71	52.17	187	150	80.21	115
133	♂ 6	"	...	109.0	87.2	40.6	63.8	46.6	42.75	58.53	176	142	80.68	102
134	♀ 11	"	...	151.1	125.0	60.5	81.7	64.5	42.69	54.07	177	142	80.23	110
135	♀ 16	"	...	159.3	132.0	61.0	88.9	71.0	44.57	55.81	195	148	75.90	125
136	♀ 17	"	...	153.0	125.2	59.8	84.1	65.4	42.74	54.97	184	150	81.52	115
233	♀ 9	"	...	127.1	103.3	47.6	70.2	55.7	43.82	55.23	175	137	78.29	104

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Adult Males

Subject No.	Age	Pedigree	Weight lbs.	Stature	Height of Acromion	Height of Dactylion	Height Sitting	Arm Length	Index of Arm Length %	Index of Height Sitting %	Length	Breadth	Cephalic Index %	Minimum Frontal Diameter
100	49	HW/H	...	174.8	141.5	66.4	93.3	75.1	42.96	53.37	200	160	80.00	119
277	51	HW/H	145	176.5	143.0	59.5	93.4	83.5	47.31	52.92	176	156	88.64	...
401	48	$\frac{7}{8}$H/$\frac{1}{8}$W	133	171.6	140.8	62.5	90.5	78.3	45.63	52.74	194	151	77.84	...
414	40	HW/H	185	178.0	147.0	66.4	91.0	80.6	45.28	51.12	181	158	87.29	...
321	22	H/HP	143	178.9	147.0	65.2	90.2	81.8	45.72	50.42	176	153	86.93	...
390	27	HP/H	150	170.6	140.1	60.4	86.9	79.7	46.72	50.94	180	147	81.67	...
405	56	WPH/H	160	173.2	144.4	62.1	90.2	82.3	47.52	52.08	179	144	80.45	...

Adult Females

Subject No.	Age	Pedigree	Weight lbs.	Stature	Height of Acromion	Height of Dactylion	Height Sitting	Arm Length	Index of Arm Length %	Index of Height Sitting %	Length	Breadth	Cephalic Index %	Minimum Frontal Diameter
58	20	H/HE	...	159.8	129.5	59.5	85.2	70.0	43.80	53.32	182	143	78.57	115
59	18	H/HIr	...	172.3	142.8	64.2	89.9	78.6	45.61	52.18	175	143	71.81	117
199	38	H/$\frac{3}{4}$WH	...	160.8	132.0	62.7	88.2	69.3	43.10	54.85	182	156	85.71	122
281	40	H/HW	196	167.7	137.7	65.2	89.0	72.5	43.23	53.07	170	148	87.06	...
288	32	H/HSc	190	157.7	129.2	63.7	89.8	65.5	41.53	56.94	168	141	83.93	...
291	40	$\frac{3}{4}$HW/H	172	171.7	144.4	67.6	88.7	76.8	44.72	51.66	181	150	82.87	...
301	18	H/HAm	95	154.1	126.0	56.0	82.2	70.0	45.42	53.34	173	140	80.92	...
307	18	H/HIr	153	162.9	133.0	62.1	88.2	70.9	43.52	54.14	178	141	79.21	...
314	36	H/HIr	147	161.0	132.7	61.8	83.9	70.9	44.03	52.11	164	152	92.68	...
323	19	H/$\frac{3}{4}$WH	140	160.7	132.3	57.3	83.4	75.0	46.67	51.90	173	138	79.77	...
325	38	$\frac{3}{4}$WH/H	197	154.9	126.8	57.3	84.4	69.5	44.87	54.49	174	140	80.46	...
336	18	HAm/H	130	159.2	129.0	62.7	87.7	66.3	41.64	55.09	175	138	78.86	...
313	20	HSp/H [5]	125	162.6	132.6	51.9	88.6	80.7	49.63	54.49	135	126	93.33	...
442	31	$\frac{3}{4}$PH/H	145	164.7	135.4	62.0	84.9	73.4	44.56	51.55	170	150	88.24	...

[5] Negro blood suspected.

TABLE IV (continued)

F_2 Family — Children of F_1 no. 128 and F_1 no. 232

Facial Measurements in Mm.								Descriptive				
Bizygomatic Diameter	Nasion Menton Height	Facial Index %	Nasion Prosthion Height	Bigonial Diameter	Nose Height	Nose Breadth	Nasal Index %	Skin Color	Hair Color	Hair Form	Eye Color	Strength
122	90	73.77	52	107	32	29	90.63	Blonde	Br−2	. . .	Br+1	. . . .
128	105	82.03	60	106	41	35	85.37	very light	Br−1	Wavy	Br+1	16–14
140	115	82.14	68	119	54	39	72.22	23+	Black	Curly	Br	32–27
140	116	82.86	69	113	52	40	76.92	23	"	"	"	30–27
124	98	79.03	—	104	37	31	83.78	light	Brown	"	. . .	9– 9
134	116	86.57	68	112	50	31	62.00	23	Br+1	Wavy	Br+1	24–21
153	127	83.01	73	133	52	40	76.92	23	Br	"	Br	38–32
143	125	87.41	74	116	53	36	67.92	23	Black	"	"	28–24
124	103	83.06	60	112	42	34	80.95	24	Br+1	Straight	"	12–12

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Adult Males

145	132	91.03	75	116	59	39	66.10	23−	Black	Curly	Br	40–32
143	120	83.92	72	. . .	58	42	72.41	*8*	. . .	"	Br−2	. . .
130	124	95.38	72	. . .	52	39	75.00	*9*	Black	Wavy	Br	. . .
138	135	97.83	80	. . .	57	40	70.18	. . .	"	"	Br−1	. . .
125	127	101.60	74	. . .	52	40	76.92	*9*	"	"	Br+1	38—
138	125	90.58	63	. . .	50	49	98.00	. . .	"	"	Br	67—
137	118	86.13	69	. . .	52	44	84.62	. . .	"	Curly	Br+1	. . .

Adult Females

134	122	91.73	71	114	53	41	77.36	23	Black	Straight	Br+1	21–17
133	116	87.22	66	107	52	39	75.00	24	"	Wavy	Br+1	28–25
143	119	83.22	69	126	48	40	83.33	23−	"	"	Br−1	27–29
133	114	85.71	67	. . .	49	39	79.59	*12*	Br+1	Curly	Br	41
126	99	78.57	58	. . .	44	40	90.91	*9*	Br+1	Curly−	Br−1	28
133	110	82.71	68	. . .	52	42	80.77	*14*	Black	Wavy	Br	37
124	109	87.90	61	. . .	41	37	90.24	*12*	"	Straight	"	17
127	111	87.40	63	. . .	50	36	72.00	*10*	"	Wavy	"	34
122	110	90.16	67	. . .	49	36	73.47	*15*	"	"	"	23
131	113	86.26	64	. . .	49	41	83.67	*13*	"	"	Br+1	31
133	116	87.22	69	. . .	49	39	79.59	*15*	"	Curly	Br+1	35
126	111	88.10	67	. . .	47	37	78.22	. . .	Br+1	Wavy	Br+1	28
109	113	103.67	66	. . .	48	38	79.17	*15*	Black	"	Br+1	25
131	115	87.79	66	. . .	46	43	93.48	. . . .	Black	Kinky	Black	. . .

TABLE IV (continued)

Immature Males

Subject No.	Age	Pedigree	Weight lbs.	Bodily Measurements in Cm.: Stature	Height of Acromion	Height of Dactylion	Height Sitting	Arm Length	Index of Arm Length %	Index of Height Sitting %	Head Measurements in Mm.: Length	Breadth	Cephalic Index %	Min. Frontal Diameter
24	17	H/HW	...	171.1	140.0	58.9	85.4	81.1	47.39	49.91	210	163	77.62	126
40	16	H/HW	...	173.0	139.0	57.0	89.0	82.0	47.40	51.44	195	148	75.90	118
46	13	HW/H	...	152.5	123.0	54.0	76.0	69.0	45.24	49.84	188	154	81.91	120
55	16	HAm/H	...	175.8	143.9	64.2	91.2	79.7	45.33	51.88	191	151	79.06	125
51	16	HW/H	...	168.3	138.3	61.8	90.2	76.5	45.45	53.59	186	154	82.80	115
460	16	HAm/H	105	159.8	130.5	55.2	81.5	75.3	47.12	51.00	177	141	79.66	...
50	17	H/$\frac{3}{4}$HG	...	179.5	145.0	63.0	89.0	82.0	45.68	49.58	184	159	86.41	115
164	13	H/HP	76	143	114.5	49.3	73.3	65.2	45.59	51.26	181	147	81.22	106
475	17	H/HP	125	169.6	138.8	59.8	85.5	79.0	46.58	50.41	183	143	78.14	...

Immature Females

Subject No.	Age	Pedigree	Weight lbs.	Stature	Height of Acromion	Height of Dactylion	Height Sitting	Arm Length	Index of Arm Length %	Index of Height Sitting %	Length	Breadth	Cephalic Index %	Min. Frontal Diameter
93	14	.....	...	148.5	120.8	56.5	80.0	64.3	43.30	53.87	173	140	80.92	109
89	17	HW/H	161	160.1	130.2	61.3	87.8	68.9	43.03	54.84	196	154	78.57	115
204	16	H/$\frac{3}{4}$HW	...	154.5	122.5	55.3	79.5	67.2	43.49	51.46	182	151	82.97	123
215	16	H/HG	...	159.5	130.9	59.8	82.5	71.1	44.57	51.72	177	149	84.18	114
253[6]	17	HW/H	...	158.3	129.6	55.2	80.5	74.4	46.99	50.85	175	152	86.86	114
254	14	H/HW	...	149.8	121.2	53.3	81.0	67.9	45.33	54.07	171	148	86.55	110
437	15	H/HFr	80	155.5	128.2	57.5	80.5	70.7	45.47	51.77	161	142	88.20	...
457	16	HAm/H	95	155.2	127.8	57.3	81.1	70.5	45.42	52.25	176	140	79.55	...
458	16	H/HW	...	155.3	126.2	56.5	80.3	69.7	44.88	51.71	180	142	78.89	...
432	17	H/HP	131	148.5	119.6	52.2	80.2	67.4	45.38	54.01	167	141	84.43	...
476	17	H/HP	121	159.5	130.3	60.0	85.9	70.3	44.07	53.85	171	139	81.29	...
102	8	H/$\frac{3}{4}$HW	...	127.2	101.2	47.7	67.3	53.5	42.05	52.90	180	140	77.78	102

Backcross × White

Adult Males

Subject No.	Age	Pedigree	Weight lbs.	Stature	Height of Acromion	Height of Dactylion	Height Sitting	Arm Length	Index of Arm Length %	Index of Height Sitting %	Length	Breadth	Cephalic Index %	Min. Frontal Diameter
168	19	HAm/E	169	175.0	143.2	66.4	89.8	76.8	43.88	51.31	197	145	73.60	122
177	25	$\frac{3}{4}$WH/W	...	171.4	139.0	63.6	90.7	75.4	43.99	52.92	195	150	76.92	118
274[7]	28	HAm/Am	125	166.5	138.0	60.0	86.9	78.0	46.84	52.19	187	155	82.89	113
482	21	HAm/Am	127	169.2	135.4	57.6	89.9	77.8	45.98	53.13	180	141	78.33	...

Adult Females

Subject No.	Age	Pedigree	Weight lbs.	Stature	Height of Acromion	Height of Dactylion	Height Sitting	Arm Length	Index of Arm Length %	Index of Height Sitting %	Length	Breadth	Cephalic Index %	Min. Frontal Diameter
60	18	HAm/No	126	159.0	130.0	60.7	83.2	69.3	43.58	52.33	176	151	85.80	115
121	19	$\frac{3}{4}$HAm/E	...	167.4	139.5	66.4	88.0	73.1	43.66	52.57	184	146	79.35	115
137[8]	25	HE/Ir	124	161.2	132.2	63.6	88.2	68.6	42.55	54.71	177	144	81.36	109
138[8]	24	"	137	170.7	143.0	66.9	93.4	76.1	44.58	54.71	187	148	79.14	112

[6] Ehu. [7] Husband of No. 275. [8] Sisters.

TABLE IV (continued)

Immature Males

Facial Measurements in Mm.								Descriptive				
Bizygo-matic Diameter	Nasion Menton Height	Facial Index %	Nasion Prosthion Height	Bigonial Diameter	Nose Height	Nose Breadth	Nasal Index %	Skin Color	Hair Color	Hair Form	Eye Color	Strength
147	135	91.84	81	115	62	40	64.52	24+	Black	Curly	Br	45–34
145	127	87.59	76	112	69	35	50.72	47	"	Wavy	Br	50–43
136	112	82.35	70	113	51	37	72.55	24	Br+2	"	Hazel	38–35
141	126	89.36	72	122	51	44	86.27	39	Black	"	Br	61–53
144	121	84.03	73	112	55	37	67.27	47	"	"	"	48–44
122	116	95.08	64	...	47	36	76.60	...	Br+1	"	Br−1	...
139	117	84.17	70	112	60	43	71.67	39	Black	"	Br+1	50–38
130	114	87.69	66	108	48	36	75.00	...	Black	Straight	Br−1	16–21
126	116	92.06	67	...	46	42	91.30	...	...	Wavy	Br+1	...

Immature Females

128	114	89.06	70	105	51	34	66.67	23−	Br+1	Wavy	Br	23–19
143	116	81.12	68	116	50	39	78.00	23	Black	Wavy	Br+1	29–29
145	115	79.31	66	132	47	38	80.85	24	"	"	Br	26–25
138	122	88.41	71	120	49	41	83.67	24	Br+1	"	Br−1	27–22
151	115	76.16	67	131	51	39	76.47	24	Bleached	"	Br	32–30
150	112	74.67	65	118	48	37	77.08	24	Black	"	Br	25–23
121	113	93.39	63	...	46	36	78.26	...	Br+1	"	Br−2	...
125	108	86.40	60	...	42	37	88.10	...	Black	Straight	Br	...
126	104	82.54	61	...	45	37	82.22	...	Reddish	...	Br+1	...
125	109	87.20	60	...	42	41	97.62	...	Br+1	...	...	...
121	113	93.39	60	...	47	37	78.72	...	...	Wavy	Br+1	...
128	102	79.69	65	102	48	32	66.67	47	Br+1	Wavy	Br+1	9–10

Backcross × White

Adult Males

144	126	87.50	69	123	52	44	84.62	—	Black	Wavy	Br+1	55–49
132	114	86.36	59	118	48	40	83.33	—	Lt Yellow	Wavy	Lt Blue	47–42
143	117	81.82	71	117	59	35	59.32	23	Br+1	Wavy	Blue	49–44
127	109	85.83	63	...	46	35	76.09	—	Br+1	Straight	Br+1	56

Adult Females

137	115	83.94	75	107	55	30	54.55	23−	Br+1	Wavy	Blue	22–22
132	129	97.73	76	110	58	34	58.62	23−	Br+1	Wavy	Hazel	26–33
135	117	86.67	70	106	58	30	51.72	23−	Br	Straight	...	25–22
132	115	97.12	70	118	56	34	60.71	23	Br+1	"	Br+1	38–37

TABLE IV (continued).

Adult Females

				Bodily Measurements in Cm.							Head Measurements in Mm.			
Subject No.	Age	Pedigree	Weight lbs.	Stature	Height of Acromion	Height of Dactylion	Height Sitting	Arm Length	Index of Arm Length %	Index of Height Sitting %	Length	Breadth	Cephalic Index %	Minimum Frontal Diameter
430	18	$\frac{3}{4}$ HAm/Sc	110	160.4	131.4	59.8	80.3	71.6	44.63	50.06	171	130	76.02	...
451	20	HE/No	135	169.8	139.0	64.0	90.5	75.0	44.16	53.30	178	139	78.09	...
445	43	HE/P	151	169.0	140.3	67.3	90.6	73.0	43.19	53.61	176	150	85.23	...
						Immature Males								
36	15	$\frac{3}{4}$ AmH/Am	....	162.0	129.0	58.1	89.0	70.9	43.75	54.94	200	149	74.50	122
49	18	$\frac{3}{4}$ EH/E	...	168.0	138.0	62.0	88.0	76.0	45.23	52.38	188	149	79.26	113
385	16	$\frac{3}{4}$ HG/Am	145	165.5	134.7	59.5	85.7	75.2	45.43	51.78	183	138	74.51	...
454	18	$\frac{3}{4}$ WH/E	173	178.4	146.8	63.6	89.3	83.2	46.63	50.06	192	138	71.88	...
468	16	$\frac{3}{4}$ AmH/Am	136	174.5	143.0	64.7	91.3	78.3	44.87	52.32	181	140	77.35	...
480	18	HW/W	136	175.4	140.8	56.6	90.4	84.2	48.00	51.54	179	140	78.21	...
462	16	HAm/P	113	161.2	132.3	58.2	80.2	74.1	45.97	49.75	174	141	81.03	...
						Immature Females								
219	17	WH/W	...	163.6	132.6	59.0	...	73.6	44.98	....	182	147	80.77	116
223	16	HW/W	...	153.2	123.2	55.0	79.9	68.2	44.51	52.15	181	144	79.56	108
426	17	HAm/Am	110	171.2	143.3	66.8	86.4	76.5	44.68	50.47	176	139	78.98	...
230	17	HW/P	...	161.5	131.2	59.1	84.7	72.1	44.64	52.45	182	150	82.42	110
231	13	HW/Sp	...	158.0	131.2	58.6	84.9	72.6	45.94	53.73	185	139	75.14	111

OTHER HAWAIIAN-WHITE MIXTURES

Males

Subject No.	Age	Pedigree	Weight lbs.	Stature	Height of Acromion	Height of Dactylion	Height Sitting	Arm Length	Index of Arm Length %	Index of Height Sitting %	Length	Breadth	Cephalic Index %	Minimum Frontal Diameter
25	16	$\frac{1}{4}$ H?/W	...	160.3	129.5	52.5	80.3	77.0	48.03	50.09	179	143	79.89	115
33	15	$\frac{3}{4}$HW/$\frac{3}{4}$WH	...	163.8	134.8	59.3	84.3	75.5	46.09	51.47	180	151	83.89	125
39	16	$\frac{3}{4}$ WH?/E	...	172.8	141.5	64.5	90.2	77.0	44.55	52.20	187	154	82.35	120
43	17	W?/H	...	169.0	139.0	62.0	85.0	77.0	45.56	50.29	198	161	81.31	127
124	16	HSpE?/WH	...	167.5	140.0	60.4	85.9	79.6	47.52	51.28	184	149	80.98	117
167	26	$\frac{3}{4}$WH/$\frac{3}{4}$WH	192	176.1	145.4	67.9	87.5	77.5	44.01	49.69	195	161	82.56	119
421	55	WH/?	187	180.4	152.2	67.2	92.5	85.0	47.12	51.27	189	154	81.48	...
						Females								
92	16	HW/HW	...	165.8	135.5	59.7	86.9	75.8	45.71	52.41	174	145	83.33	113
103	13	H/W ?	...	149.3	120.5	55.5	80.5	65.0	43.53	53.91	184	144	78.26	112
119	26	EH/AmH	162	162.4	133.6	62.0	86.6	71.6	44.09	53.33	186	155	83.33	118
158	17	AmH/AmH	116	150.2	121.2	54.4	79.8	66.8	44.47	53.13	179	140	78.21	109
290	26	HW/HW	165	168.7	139.1	66.0	89.2	73.1	43.33	52.87	170	143	84.12	...
447	16	H/$\frac{7}{8}$ Ir	140	154.6	128.6	60.6	84.6	68.0	43.98	54.72	168	142	84.52	...
449	16	HG/HP	110	161.9	131.3	58.5	84.1	72.8	44.96	51.95	161	141	87.58	...
450	16	.....[9]	...	155.7	126.3	56.4	81.1	69.9	44.89	52.09	173	144	83.24	...
497	17	HW/HW	150	157.1	127.6	59.9	85.9	67.7	43.09	54.68	178	137	76.97	...

[9] Father 1/2 Hawaiian, 1/4 English, 1/4 Portuguese; Mother 1/2 Porto Rican, 1/2 Spanish.

TABLE IV (continued).

Adult Females

Facial Measurements in Mm.								Descriptive				
Bizygomatic Diameter	Nasion Menton Height	Facial Index %	Nasion Prosthion Height	Bigonial Diameter	Nose Height	Nose Breadth	Nasal Index %	Skin Color	Hair Color	Hair Form	Eye Color	Strength
117	107	91.45	55	...	41	32	78.05	...	...	...	Br−1	...
124	111	89.52	59	...	44	35	79.55	...	Br	Straight	Br	...
129	113	87.60	65	...	53	37	69.81	...	Black	Wavy	Br	...
Immature Males												
139	129	92.81	77	114	57	35	61.40	24	Br	Straight	Br−1	38–34
136	107	78.68	65	113	50	33	66.00	23	Br	"	Br	41–35
121	119	98.35	67	...	45	37	82.22	...	Br	Wavy	Blue	51
125	115	92.00	64	...	50	38	76.00	2	Br−1	Curly	Blue−	...
123	110	89.43	62	...	46	32	69.57	...	Br	...	Br	...
129	123	95.35	71	...	56	36	64.29	...	Br	Straight	Br	41
125	112	89.60	63	...	45	35	77.78	...	Br−1	...	Br	...
Immature Females												
135	113	83.70	66	127	47	37	78.72	Light	Br	Wavy	Br−1	30–28
136	112	82.35	63	124	48	35	72.92	"	Br−1	...	Blue	11–11
123	107	86.90	61	...	43	34	79.07	...	...	...	...	...
136	120	88.24	67	118	48	32	66.67	23	Black	Wavy	Br	31–30
133	111	83.46	70	124	51	35	68.63	24	"	Straight	Br	19–16

Other Hawaiian-White Mixtures

Males

Bizygomatic Diameter	Nasion Menton Height	Facial Index %	Nasion Prosthion Height	Bigonial Diameter	Nose Height	Nose Breadth	Nasal Index %	Skin Color	Hair Color	Hair Form	Eye Color	Strength
137	114	83.21	70	108	54	39	72.22	33	Br+1	Wavy	Br	39–36
145	123	84.83	73	121	52	42	80.77	47	Black	"	"	32–31
143	123	86.01	75	118	60	39	52.20	24	Br−1	Straight	Hazel	50–42
155	135	87.10	85	124	64	41	64.06	40−	Br	Wavy	Br	60
140	129	92.14	73	110	53	35	66.04	47	Br+2	Curly	Br	34–28
154	117	75.97	70	134	52	39	75.10	...	Br	Wavy	Hazel	41–39
142	137	96.48	74	...	55	44	80.00	...	Black	"	Br	...
Females												
133	117	89.97	68	112	51	40	78.43	24	Br+1	Wavy	Br	38–29
132	113	85.61	67	110	53	36	67.92	47	Black	"	Br	20–18
138	120	86.96	73	119	50	35	70.00	24−	Br+2	Straight	Br	24–20
122	112	91.80	62	107	43	33	76.74	24−	Black	Curly	Br	19–18
130	111	85.38	65	...	49	39	79.59	13	Br+1	Wavy	Br	27
126	104	82.54	57	...	40	33	82.50	...	Black	"	Br	...
121	121	100.00	65	...	43	34	79.07	...	Br+1	...	Br+1	...
118	112	94.92	59	...	46	34	73.91	...	Br+1	"	Br	...
120	111	92.50	58	...	41	32	78.05	...	Br	Curly	Blue	...

TABLE V. HAWAIIAN WHITE CHINESE

Subject No.	Age	Sex	Pedigree	Weight lbs.	Bodily Measurements in Cm.							Head Measurements in Mm.			
					Stature	Height of Acromion	Height of Dactylion	Height Sitting	Arm Length	Index of Arm Length %	Index of Height Sitting %	Length	Breadth	Cephalic Index %	Minimum Frontal Diameter
189	22	♂	HN/C	132	173.8	140.4	62.4	83.2	78.0	44.76	47.87	197	155	78.68	114
27	16	♂	HC/N	...	164.7	133.0	60.5	86.1	72.5	44.02	52.28	173	146	84.39	113
35	16	♂	HN/HC	...	155.7	124.5	51.5	82.2	73.0	46.89	51.52	174	155	89.08	117
38	14	♂	CH/N	...	158.0	126.5	56.5	84.9	70.0	44.30	53.73	193	150	77.72	113
41	15	♂	CH/H	...	160.0	130.0	60.0	84.0	70.0	43.75	52.50	187	153	81.82	110
463	14	♂	HN/C	102	153.2	122.8	53.5	79.2	69.3	45.23	51.70	172	139	80.81	...
473	16	♂	HH/NC	115	157.9	127.1	55.4	80.6	71.7	45.41	51.04	159	137	86.16	...
483	17	♂	P/HC	120	161.4	131.3	57.5	85.6	73.8	45.44	52.71	174	140	80.46	...
159	18	♀	CH/NH	120	156.5	129.8	58.4	82.5	71.4	45.62	52.71	166	155	93.37	113
293	21	♀	C/CHN	115	159.0	127.6	58.8	86.1	68.8	43.27	54.15	170	134	78.82	...
306	20	♀	HN/HC	145	162.9	132.4	61.0	87.5	71.4	43.56	53.39	172	147	85.47	...
334	27	♀	NH/C	...	164.0	133.6	61.1	86.4	72.5	44.21	52.68	166	136	81.93	...
90	16	♀	HC/N	143	154.7	125.5	58.5	83.5	67.0	43.31	53.97	180	156	86.66	123
182	14	♀	HC/N	...	158.4	128.1	54.7	79.9	73.4	46.34	50.44	178	145	81.46	111
111	11	♀	H(C?)/NH	...	144.2	116.5	51.6	73.7	64.9	45.01	51.11	169	145	85.80	107
217	16	♀	HN/CH	...	163.6	130.3	55.5	87.7	74.8	45.72	53.61	176	146	82.95	118
234	16	♀	CH/NH	...	153.5	124.3	56.4	80.2	67.9	44.30	52.25	164	146	89.02	111
248	17	♀	CH/Sp	...	158.0	129.2	59.3	85.7	69.9	44.30	54.24	181	150	82.87	108
273	15	♀	HC/N	...	159.0	127.4	57.8	86.0	69.6	43.77	54.09	186	144	77.42	116
434	17	♀	SpH/HC	...	150.7	123.4	57.6	75.0	65.8	41.91	49.77	161	141	87.58	...
492	17	♀	HC/HN	125	158.0	129.3	56.9	80.9	72.6	45.66	50.88	174	133	76.44	...
498	17	♀	HSpC/HC	105	155.6	129.3	60.2	79.1	69.1	44.41	50.83	163	138	84.66	...
499	17	♀	HC/P	...	152.0	124.9	56.7	79.5	68.2	44.87	52.30	162	141	87.04	...
501	26	♂	NH/HCN	160	177.1	147.0	65.4	88.5	81.6	46.07	49.97	178	137	76.97	...
503[1]	9	♂	HC/HNC	...	123.6	96.8	39.7	64.5	57.1	46.20	52.18	162	132	81.48	...
504[1]	6	♂	"	...	107.9	82.5	34.9	55.5	47.6	44.11	51.44	155	127	81.93	...
505[1]	5	♀	"	...	106.5	....	...	53.5	...	....	50.23	146	127	86.99	...

[1] Children of ♂ 501 and ♀ 502 (F_1 Hawaiian × Chinese).

TABLE V. HAWAIIAN WHITE CHINESE

Face Measurements in Mm.							Descriptive					
Bizygomatic Diameter	Nasion Menton Height	Facial Index %	Nasion Prosthion Height	Nasal Height	Nasal Breadth	Nasal Index %	Skin Color	Hair Color	Hair Form	Eye Color	Strength	Eye Fold
142	140	98.59	81	58	40	68.97	—	Black	Straight	Br−2	57–47	—
129	126	97.67	71	51	41	80.39	23	Br+2	"	Br	45–49	—
142	127	89.44	77	58	41	70.69	40−	Black	Wavy	Br+1	42–49	—
128	113	88.28	66	47	36	76.58	24−	"	Straight	Hazel	27–30	—
126	110	87.30	64	52	39	75.00	23	"	Wavy	Br	37–37	—
129	104	80.62	62	41	36	87.81	—	"	Straight	Br+1	—	+
122	108	88.52	60	43	40	95.24	—	"	"	"	47−	+
126	116	92.06	66	45	35	77.77	*11*	Br+1	Wavy	Br	51−	±
139	116	83.45	63	46	38	82.61	23−	Br	"	Br−1	25–24	±
129	110	85.27	65	47	34	72.34	—	Br+1	Straight	Br	24−	0
109	112	102.75	67	49	42	85.71	*12*	Black	Wavy	"	30−	0
130	105	80.77	59	47	36	76.59	*15*	"	Straight	Br+1	33−	0
144	125	86.81	74	54	40	74.07	23	"	Wavy	Br+1	24–24	±
139	123	88.49	76	55	35	63.63	Blonde	Br+1	Straight	Hazel	21–17	—
125	116	92.80	71	49	33	67.35	47−	Br+1	Wavy	Br+1	16–17	+
135	118	87.41	67	51	39	76.47	24	Black	Straight	Br	25–22	—
138	113	81.88	65	49	38	77.55	light	Br+1	"	Br−1	27–26	—
140	122	87.14	74	52	38	73.07	23	Black	Wavy	"	33–34	—
136	115	84.56	68	50	40	80.00	23	"	Curly	Br	31–34	±
124	99	79.84	58	39	39	100.00	—	"	Straight	Br+1	—	0
126	111	88.09	66	49	34	69.39	—	Br+1	Wavy	Br	—	+
131	112	85.50	65	43	33	76.74	—	Black	"	"	—	+
124	105	84.68	58	40	37	92.50	—	"	"	Br+1	—	0
129	115	89.15	67	44	40	90.91	—	Black	Curly	Br−1	—	0
—	95	—	57	38	33	86.84	...	"	Wavy	Br+1	—	0
—	84	—	45	39	31	79.49	...	Br+2	"	Br	—	0
—	81	—	45	31	32	103.23	...	"	"	Br	—	0

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PAPERS

OF THE

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Vol. XI. — No. 4

AZILIAN SKELETAL REMAINS FROM MONTARDIT (ARIÈGE) FRANCE

BY

RUTH OTIS SAWTELL

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*SEVEN PLATES AND TWO ILLUSTRATIONS
IN THE TEXT*

CAMBRIDGE, MASSACHUSETTS, U.S.A.
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CONTENTS

LIST OF ILLUSTRATIONS

PLATES

FIGURES

INTRODUCTION

THE SITE

The rock shelters of Montardit are surrounded by famous caves of the French Pyrenees. The Mas d'Azil, Tuc d'Audoubert, Trois Frères, and Enlène lie within a few miles, and on all sides the limestone of the Plantaurel is pierced by hundreds of caves, many of which have yielded traces of industry from which the palaeolithic past has been reconstructed. During excavations of the largest of the Montardit shelters, a small cave well known in the local *patois* as the *Tuto Biouleto* (*Trou Violet*), the Violet Hole, certain human skeletal remains were discovered associated with fauna and implements of stone and bone which dated them as definitely Azilian.

The work of the first field season, 1924, undertaken by Paul and Ida Treat Vaillant-Couturier and the present writer, then Radcliffe traveling fellow in science, was made possible by the interest and enthusiasm of the late Mrs. William G. Farlow of Cambridge. The excavations of 1925 and 1926 were carried on by Monsieur and Madame Vaillant-Couturier under the patronage of the Institut de Paléontologie Humaine de Paris. The human skeletons are now in the Musée d'Histoire Naturelle de Paris, together with the greater part of the animal bones and artifacts; a small collection representing the Azilian industry and fauna was presented to the Peabody Museum of Harvard University.

Through the great courtesy of Professor Boule and Professor Verneau of the Musée d'Histoire Naturelle de Paris, the writer was able to study the Azilian skeletons in their laboratories, together with other rare prehistoric remains, notably the three Cro-Magnon crania. Monsieur Paul Clavelin of the *Laboratoire d'Anthropologie* was unfailing in help and kindness. For advice in the preparation of this monograph, gratitude is expressed to Professor Earnest A. Hooton of Harvard University.

STRATIFICATION

Five distinct strata were disclosed in the excavation of the *Trou Violet*. These strata, their peculiar fauna and industry, have been thoroughly described by the Vaillant-Couturiers, and it is from their study that these statements are summarized.[1] From bottom to top the strata ran:

A. Clay, friable and sterile, resting on the rock floor of the cave.
B. Yellow clay containing Magdalenian hearths and reindeer bones.
C. Clay, muddy, containing pieces of limestone, cobblestones, bones of rodents and birds, and covered in certain spots by a deposit of stalagmite.
D. Black earth, striped with red, containing many Azilian hearths, fauna characteristic of that period, and an abundance of Helix.
E. Disturbed earth, Neolithic and Gallo-Roman remains.

Stratum D, the Azilian layer, began at 1.40 m. below the cave surface of 1924. Sixty centimeters down in this layer — two meters from the top — was found the first Azilian burial. This was on August 28, 1924. Ten days later, at an additional depth of 50 cm., the second grave came to light. The trench at the back of the cave had reached the level of an archway, the entrance of which was closed by great blocks of limestone. Removal of these blocks disclosed a small chamber 1.50 m. in length. The first human skeleton (Montardit I) lay with the skull vault against the springstone of this arch. It had been placed on the right side, completely extended, the head higher than the feet, the body inclined downward and inward toward the back of the small chamber. Across the legs a large flat stone had been set, and the grave was roughly outlined by eighteen cobblestones, one with traces of red. Numerous other stones showing use as hammers, anvils, etc., and marked with red, or blackened from fire, were found within this circle. A large flint chip crudely worked was the only implement. The remains of the second human skeleton (Montardit II) were also buried within a second archway, shallower than the first, also closed by a pile of limestone blocks. Although few bones were found, in contrast to the almost complete preservation of Montardit I, the number of stones outlining the grave and the objects within greatly

[1] *L'Anthropologie*, vol. xxxviii (1928), pp. 217–243. Several photographs accompanying this article appeared in the study above; others are used through the courtesy of D. Appleton and Company.

exceeded those of the first burial. The type of objects was the same, even to the great crude *râcloir*. Beside the skull was found a small scraper (*grattoir sur bout de lame*).

Both hearths on which the burials were made contained the same fauna, characteristically Azilian: *Sus scrofa, Cervus elaphus, Capreolus, Bos sp., Canis lapus, Felis sylvestris, Mustela foina, Meles taxus, Mustela martes*, rodents and birds. Above and below the two graves continued hearths filled with remains of the same animals and with typical Azilian implements of stone and bone. There is no question, then, of burial at a later date.

DESCRIPTION OF SKELETAL REMAINS

OSTEOLOGICAL CATALOGUE

Skeletal remains of four individuals have been found in the *Trou Violet*; two represented by one bone each, and the two Azilian burials excavated in 1924.

Montardit A. Portion of the left side of the pelvis of a young individual. Picked up on the surface by the Abbé Cistac and M. Vaillant-Couturier in 1905.

Montardit B. Right humerus of a small, non-muscular subject, probably female. This was found in July, 1924, in the disturbed stratum (E) and is therefore of uncertain period. The distal extremity and about one-half of the shaft were present. The shaft, rounded and smooth, with middle diameters of 19 mm. and 16 mm., was in marked contrast to the rugged, relatively massive bone of the first Azilian burial. The middle shaft index (84.2) indicates less flattening than in any of the group means cited by Martin, the nearest being 83, the mean for the right humerus of white American females.

Montardit I. Skeleton of an old male, the first of the two Azilian burials. The condition of the cranium and long bones was sufficiently good to warrant a fairly complete series of measurements and detailed morphological observations. The following bones were present:

Cranium. Calvaria complete except for anterior half of both temporals and portion of right parietal and frontal. Base and most of face lacking (Plates 1 and 2). Maxilla present (Plate 3). Mandible complete except for right ascending ramus (Plate 4).

Clavicles. Left, complete. Right, lateral portion only.

Scapulae. Right and left, glenoid cavities, coracoid and acromion processes, part of axillary borders.

Sternum. Gladiolus, right side complete.

Ribs. Fragments of 18. Slender.

Pelvis. Portion of right and left ilia with acetabula. Left crest. Sacrum, fragment of first segment.

Vertebrae. Cervical 3; dorsal 8; lumbar 4 (Plate 7); sacral 1; coccygeal 0; total 16. Miscellaneous fragments.

Femora. Right, complete except for small portion of internal surface of interior condyle (Plate 5). Left, portions of both condyles, neck, and head.

Tibiae. Right, complete. Shaft below head shows some crushing inward (Plate 5). Left, lower half of shaft and part of head.

Fibulae. Left, complete. Right, distal extremity.

Humeri. Right, part of head missing. Left, lower half of shaft and most of head.

Radii. Right, shaft from below bicipital tuberosity to beginning of extremity. Left, head and shaft to beginning of extremity.

Ulnae. Right, styloid process and articulation for radius missing. Left, complete (Plate 6).

Foot and Hand. Os calcis, right and left almost complete. First left metatarsal; left cuboid, fragment; 3rd metacarpal, right and left; 4th left metacarpal; fragments of 1 metacarpal and 1 metatarsal.

Montardit II. The Second Azilian Burial. Remains of an individual, probably male, much younger than Montardit I.

Calva. Major portion of parietals; part of occipital and of right frontal. Temporal border of left parietal and piece of right frontal found apart from calva, distinctly warped and possibly gnawed.

Clavicle. Right, almost complete.

Scapula. Right, fragment inferior angle, junction of vertebral and axillary borders.

Patella. Right, complete.

Ribs. Fragments of three.

Footbones. Cuboid, right; scaphoid, left; internal cuneiform, right; metatarsals, first right, fourth right and left.

AGE AND SEX OF AZILIAN SKELETONS

Montardit I. The burial found in the first Azilian hearth, two meters from the level of 1924, was presumably that of an old man. Of the areas where age changes are most definitely indicated, the symphysis pubis was absent, but the excessive wear of the teeth (Plate 4), the condition of the palate, — constricted, senile, and diseased (Plate 3), — and the vertebrae with their depressed centra and arthritic borders (Plate 7), all pointed to more than middle life. Moreover, the state of the cranial sutures agreed with this conclusion. Viewed from the inner surface, the coronal and temporo-lambdoid sutures were entirely closed, the sagittal was three-fourths obliterated, and of the lambdoid, only traces remained. On the outside, the coronal was visible only in the temporal region (Plate 2), the lambdoid almost obliterated (Plate 1), the sagittal present only at bregma and obelion, and the temporo-occipital open.

Sex differentiation in the cranium was most marked in the heavy brow-ridges and rugged mastoids, both remarkable for so small a skull. The skull base and zygomata being absent and the palate senile, the only other evidence was furnished by the mandible. The menton and the gonial angles were strongly marked; the other characters were definitely masculine. Of the other bones, the fragmentary pelvis offered little. The ischiatic notch was deep and of medium width; the spines were broken. On the right, the preauricular sulcus showed a sharp line; on the left, it was less clearly marked, but with no roughness.

All the long bones were sturdy with heavy musculature, and the heads of femur and humerus were large both actually and relative to the shaft (Plate 5).

The balance of evidence thus seems to justify the conclusion that the first Azilian skeleton was male and old. Of the second, while almost none of the decisive characters were present, on the basis of its greater thickness and similar size, and of the prominent occipital torus, seems also male. The suture closure — internal, all open; external, all open except the sagittal around obelion — indicates a young individual.

CRANIAL CHARACTERS OF AZILIANS OF MONTARDIT

As nearly as one can judge from its present state, the cranium of Montardit II in *norma verticalis* resembled a slightly broadened ellipse, with a parietal breadth approximating 136 mm. There is definite flattening at and just above lambda. These traits are equally characteristic of Montardit I, but the occipital torus, a ridge marked but not extremely rugged, is in contrast to the inion of Number I. Both skulls show suture patterns of medium complexity. The coronal suture of Montardit II is very simple, the others grading from medium to complex. Several small Wormian bones appear in the sagittal suture, and the left portion of the lambdoid contains one large and one small. In both crania, there is one very large parietal foramen and several of minute size.

The most outstanding characteristic of this fragmentary skull is the thickness of the frontal bone. At bregma, it measures 9 mm., and at 2.5 mm. lower, 10 mm. The mean thickness of the left parietal above the temporo-parietal suture is, however, only 3.6 mm. The relation this bears to other prehistoric skulls will be discussed later.

Of those personal experiences both post- and ante-mortem which individualize even so remote a specimen, this cranium had its share. Two healed depressed lesions mar the surface of the parietals, a small one on the right, and on the left, 38 mm. from obelion, a depression 12×6 mm. in diameter. Whether from the early disturbance of the grave already mentioned or from the wear and tear of the following ages, numerous scratches cross both parietals, those on the portion of the frontal and parietal found outside the sepulture being deepest. At the point where the frontal ends, the roughness of the bone suggests gnawing, but is equally and more probably indicative of long contact with earth and stone. In view of the fact that clavicle, patella, and footbones were found in approximately normal relationship to the calva, the suggestion offered by the Abbé Breuil that the scratches mean preparation and ceremonial burial of the Le Placard type does not seem probable.

Montardit I. *Calvarium—Measurements.* On the calvarium of the first Azilian skeleton it was possible to take the following measurements.

Glabello-occipital length 180 mm.; maximum transverse breadth 136.5 mm.; auricular height 117 mm. These, with the length-breadth and length-auricular height indices of 75.83 and 65, show a small skull at the lowest limit of mesocephaly and well within the hypsicephalic division of Martin. The maximum circumference above the brow-ridges approximated 510 mm. The height of the rather low right orbit was about 30 mm., and the nasal breadth measured 24 mm. The cranial bones showed considerable thickness. On the left parietal just above the temporo-parietal suture, the mean was 5.3, about that obtained by Boule on the Neanderthal man of La Chapelle-aux-Saints, 2.6 mm. thicker than the Old Man of Cro-Magnon, and 1.7 mm. thicker than the same region of Montardit II. The frontal region at bregma, however, was 6 mm., the same as Cro-Magnon I, whereas the Neanderthal specimen measured 8 mm. and Montardit II, 9 mm. At 2.5 mm. below bregma, where Montardit II shows its greatest thickness of 10 mm., Montardit I remains 6 mm., while the Cro-Magnon frontal increases to 7 mm. It must be borne in mind, however, that Montardit I is a much older individual than Montardit II.

By the Lee-Pearson formula 10 *bis*, a cranial capacity of 1389 was computed, an amount small but well within the range of all modern European groups listed by Martin.

Measurements of the palate were unsatisfactory because of senility and state of preservation, but a tentative index of 110.35 supports the observation of original narrowness.

The degree of completeness of the mandible allowed these four measurements: height of symphysis, 31 mm.; minimum breadth of left ascending ramus, 32 mm.; height of ramus, 53 mm.; condylo-symphysial length, 100 mm.

Discussion of these measurements will be found in relation to the morphological observations, and in comparison with other crania of the Stone Ages.

Montardit I. *Calvarium—Morphological Observations.* The frontal region of the skull was of average height, the slope gradual and of medium steepness (Plate 2). The breadth was apparently medium (Plate 1). There was a slight median ridge. Brow-ridges heavy and protruding surmounted each orbit, but with no extension above nasion of the torus type. Below these ridges, the glabella was prominent and protuberant, and the upper border of the orbit showed great thickness.

Viewed in *norma verticalis*, the sagittal region formed a somewhat widened ellipse of medium breadth. No elevation or post-coronoid depression broke the continuous curve to the region just above lambda, where the same flattening already mentioned in Montardit II occurs. The curve again continues throughout the perfectly convex, non-protuberant occipital region with its small, definitely marked inion. The temporal region was probably of medium development. Large supra-mastoid crests were present, more pronounced on the left than on the right, and the mastoids were big for so small a skull and quite rugged.

Sutures were apparently of medium pattern, and almost entirely obliterated, as has been stated above. Several Wormian bones of small size were present in the right and left portions of the coronal suture; one large example appeared as lambda, and one large left, one medium right, and various ossicles in each side of the occipital suture. In the sagittal suture, a parietal foramen of considerable size with a smaller perforation at the left recalled a similar occurrence in Montardit II.

MAXILLA AND MANDIBLE

Although too great an area was lacking to permit the attachment of maxilla (Plate 3) to calvarium, the condition of both upper and lower jaws made possible a fairly complete study of the face of the Montardit Azilian. The orbits were rather low, rhomboid in shape, and of medium inclination. The nasal root was depressed to a moderate degree, the spine small, and the lower borders of the aperture not sharply defined. No trace of alveolar prognathism was discernible; facial prognathism could not be ascertained. The hard palate, now distorted by senility and with the alveolar borders eaten and absorbed by abscesses, doubtless had a narrow parabolic form. The mandible (Plate 4) was of medium size, with a strong body and ascending rami moderately broad but very thin. The sigmoid notch was not deep. The inferior dental foramen was unusually large; the eversion of the gonial angles strongly marked; the chin was positive, a rough oval in form. On the inner surface two characters offered marked evolutionary conflict — the almost complete absence of the mylo-hyoid ridge, reminiscent of the anthropoid, associated with an ultra-human development of the genial tubercles.

DENTITION

When the jaws were disinterred, eight teeth were more or less present; none were found in the grave. While all of these teeth showed excessive wear, there were no signs of caries. The teeth present were the upper left canine and the mesial fang of the upper left first molar (Plate 3); in the mandible (Plate 4), root of the canine, first right premolar, all three right molars, left first premolar. Of the upper teeth missing, all four premolars were probably lost in life. Their sockets are pitted and eaten by abscesses and possible pyorrhoea, and traces of the same condition extend throughout the molar region.

While the borders of the lower jaw show less evidence of inflammatory processes than does the maxilla, the enlargement of the socket for the right second molar and its extension over the buccal surface probably denotes an abscessed condition. Both central incisors and possibly the left second incisor were lost in life and the processes were absorbed. The third molar is much less worn than any of the other teeth. The first and second molars are of equal size, again an anthropoid trait, but the canines are non-projecting and there is no other hint of characters less than typically human.

EXTREMITIES

The limb bones of the Montardit Azilian characterize him as a short, muscular man with no apelike and few primitive traits.

The right femur (Plate 5) measures 407 mm. bicondylar and 415 mm. maximum. At mid-shaft, the antero-posterior diameter is 27 mm., the transverse 23 mm.; the corresponding subtrochanteric diameters 22 mm. and 28 mm. The shaft of the left measures 28 mm. × 23 mm., and, subtrochanteric, 22 mm. and 28 mm., being about identical with the right. The head of the right bone is of large diameter, 45 mm. maximum, and shows a moderate degree of torsion. Shafts are prismatic in section, with pronounced curvature, of greater degree in the left. The compensating pilaster is also greater on this bone, being 7 mm. broad at the middle, while the maximum for the right is 6 mm. The index of pilaster (Martin) is 117.39 for the right and 121.74 for the left. Both indices are higher than in any of the racial averages given by Martin, with the exception of Eskimos, Veddahs, and Australians, but so great is the individual variation in all groups both ancient and modern that even the Montardit left femur falls from five to ten points below the upper limit of the range for groups cited. Means for various peoples run as follows: Cro-Magnon 111.6; France, Neolithic 111.1; France, Mediaeval 105.1; France, Modern 107.8. Measurements of a pair of fragmentary femora from the *couche de galets* of the Mas d'Azil (Musée de St. Germain) gave for the right an index of 114.29 and 113.64 for the left. Since a record of shaft diameters on the Mugem skeletons cannot be found and no long bones accompanied the burials at Ofnet and Kaufertsberg, the femora from Montardit and the Mas d'Azil give us our only indication of the condition in the Mesolithic period. While in relation to modern Europeans this pronounced pilaster may be considered primitive, the fact that it is the opposite condition from that found among Neanderthal man and the anthropoid apes suggests that it is an ultra-human character.

A moderate degree of platymeria characterizes the subtrochanteric region of the Montardit femora, the index, identical for each side, being 78.57. The Azilian femora from the Mas give indices of 84 and 81.48, still within the limits of platymeria, and illustrating Martin's statement that the condition is usually less pronounced on the right. The Neanderthal mean given by Boule is 80; the Cro-Magnon 72.2; various groups from France: Neolithic 75.1; Mediaeval 82.3; Modern 85.3. In general pronounced antero-posterior flattening is more characteristic of primitive peoples, but Boule states that the variability of this character is extremely high and its relation to the anthropoid condition uncertain and of little significance. The lineae asperae of the Montardit femora are strongly marked, particularly on the left, where the pilaster is also greatest. Subtrochanteric cristae and fossae are prominent. On the neck no "squatting facets" could be discerned.

The right tibia of Montardit I (Plate 5) has a maximum length of 345 mm. The antero-posterior and transverse diameters of both left and right are 29 mm. and 22 mm., index 75.86. Below the nutritive foramen, the right diameters, 34 mm. and 23 mm., give the index of 67.65. The index of a tibia from the Mas d'Azil (St. Germain Collection) is also mesocneme, 65.62. This comparative absence of flattening is associated with pronounced backward inclination of the head and an S-shaped shin crest of remarkable sharpness. All these features are also present in the Mas d'Azil specimen. The external surface of the tibial shaft is concave (the opposite side convex). The surface of the external condyle of the head is concave. On the articular surface of the lower extremity are well defined supplementary facets for the astragalus. Unfortunately both astragali are missing.

In relation to the thigh, the leg of this Azilian male was rather long (tibio-femoral index, 84.77). This value, slightly higher than the Cro-Magnon mean and much above the Solutrean Aurignacian 79.9,[1] corresponds with that of the Guanches of Teneriffe, Malays, Peruvians, and several Negro groups, a variety too wide, as Hooton points out,[2] to have great significance in racial diagnosis. More or less primitive peoples, as he says, tend to have higher

[1] Skeleton 3, season 1922–1923.

[2] *Ancient Inhabitants of the Canary Islands*, Harvard African Studies, vol. VII, pp. 85–86.

indices than Europeans, but there is no reason to consider this a negroid feature.

The complete left fibula, with a maximum length of 337 mm. and a shaft of no clear-cut type (Hrdlička 4), is without extraordinary features, but a fragment of fibula from the Mas d'Azil in contrast showed an extremely flattened section, and surfaces deeply channelled.

On the bones of the upper extremity, fewer accurate measurements were possible. The humeri, of which parts were present, are short, sturdy bones, the length of the right approximating 280 mm. Both shafts are prismatic in section, with middle diameter indices of 85.7 and 85. The heads were large, the diameter of the nearly complete right being 44 mm. There is no bowing of shaft.

In both radii, however, the curve is pronounced. Bicipital tuberosities are well developed. Shafts of radii and ulnae as well are of prismatic form. The maximum length of the left ulna is 252 mm.; the right 240 mm. without the extremity and styloid process, which measures 10 mm. on the left (Plate 6). If the pathological condition of the ulna has caused some shortening of the bone, it must always have been longer than the right. In lateral view, the normal right bone shows no curvature.

STATURE

The height of the Montardit Azilian was just under 160 cm. Since the skeleton still possessed an entire femur, tibia, and fibula, it was possible to reconstruct the stature according to the tables of Manouvrier and the formula of Pearson. By the latter method based on femur and tibia, the stature is 159.8 cm. The Manouvrier mean for femur, tibia, and fibula is 160.3 cm.; for femur and tibia alone, 160.2 cm. With the addition of figures based on the ulna, however, it rises to 161.3 cm. Similar comparisons based on femur, humerus, and ulna of the man of Chancelade give the same results: Manouvrier — femur, humerus, ulna, 160.3 cm.; Manouvrier — femur, humerus, 158.0 cm.; Pearson — femur, humerus, 157.7 cm. This seems to bear out Pearson's statement that if the stature-ulna correlation worked out as did the correlation between stature and radius, this bone would give very exaggerated results for primitive man.[1]

[1] *Philosophical Transactions*, vol. CXII, Ser. A (1899), p. 207.

While in the case of other fossil skeletons, such as an Aurignacian from Solutré and three of the five Cro-Magnons from the caves of Mentone, the stature calculated from the ulna does not exceed that from the tibia or humerus, it is always above the mean, and evidently more variable and unreliable than the other bases of calculation.

The stature, then, of Montardit I we shall consider as 159.8 cm. (Pearson formula, now used throughout the paper). Long bones of two individuals, cultural contemporaries, from the Mas d'Azil were available for some slight comparison. One, the tibia of a small, probably female, subject, in the Musée de St. Germain-en-Laye, gives a stature of 145.0 cm. The other, a femur, evidently in perfect condition, is represented life-size in one of the plates made for the unfinished volume of M. Piette. Professor Boule brought this to the writer's attention, and since the bone itself could not be discovered in the Collection Piette at St. Germain, the maximum length (447 mm.) was measured from the plate. The stature obtained therefrom of 165.3 cm. is five and one-half centimeters taller than from the femur of Montardit.

The other Mesolithic burials which have yielded long bones, the shell heaps of Mugem, also indicate a short people. Seven male skeletons average 157.5 cm. ± 3.9, and two female statures are 147.8 cm. and 152.0 cm.

The known examples of the Mugem and Montardit peoples, then, fall at the upper limit of the group of lowest stature, 159.9 cm. (Martin). Few groups of European males have means of less than 164 cm., and the prehistoric and early historic groups also given by Martin offer no close comparisons except the Chancelade Magdalenian and two groups of Neolithics from France.

VERTEBRAE

Thirteen of the sixteen vertebral segments of Montardit I were measureable at least in part. Wherever possible this was done according to the methods in Martin's *Lehrbuch*, partly as documentation, but chiefly because the cervical vertebrae are, apart from the skull, the only human bones found at the Azilian sites of Ofnet and Kaufertsberg.

Those measurements of the cervical and dorsal region for which comparative data could be found are given below. Other than the fact that the Montardit vertebrae, like most parts of the skeleton, are generally smaller than in most modern Europeans, they do not seem particularly significant.

All vertebrae show the lightness of age, and in all regions there is some evidence of arthritis (Plate 7).[1] Both foramina for the vertebral artery of the fourth cervical are subdivided. Owing to the degeneration of the lumbar region, no accurate measurements of ventral heights were possible. Dorsal heights of the last four are: 27 mm., 27 mm., 28 mm., 23 mm.

SHOULDER–GIRDLE AND PELVIS

The remains of the scapulae of Montardit I and II warrant little description. Both have heavy axillary borders. The left acromion of Montardit I, almost complete, is of medium size. The groove for the *subscapularis* muscle is prominent, particularly on the right bone. At three centimeters below the glenoid cavity — where Testut found a breadth of 18 mm. on the Chancelade man — the Montardit scapula measures 13 mm.

From each Azilian grave one clavicle was disinterred. The left of Montardit I was 140 mm. long; the right of Montardit II was about the same length, but a sturdier bone with a curve less pronounced than that of Montardit I.

The sternum of Montardit I was represented by the gladiolus nearly complete, 95 mm. in length and with a maximum thickness of 10 mm. No fossil and little other comparative material could be found. Hrdlička[2] gives these averages for Munsee Indians: maximum thickness, males 13 mm., females 10 mm.; minimum, male 10 mm., female 8 mm. The Montardit gladiolus has facets for six ribs.

For the pelvis, all that can be said has already been mentioned under Age and Sex.[3]

PATELLA AND FOOTBONES

Patella. Oddly, the scanty remains of Montardit II, unlike the more complete skeleton, included the right patella. It is apparently of average size, the maximum height and breadth approaching each other, although not so closely as in modern Whites or in the Lenapé Indians.

[1] See Pathology, p. 233.
[2] *Physical Anthropology of the Lenapé*, p. 72.
[3] See p. 221.

Table 1. Vertebrae

AXIS

	Height: Maximum	Height: Without Odontoid	Diameter of Body: Antero-posterior	Diameter of Body: Transverse
Montardit	37.5	22.0	17.0	19.0
Kaufertsberg	33.0	19.0	(16.0)	14.0
3 ♂ Ofnet	39.5	21.5	16.5	18.0
8 ♀ Ofnet	35.0	21.5	15.0	17.5

III CERVICAL

	Height			Sagittal Diameters			Transverse		Indices	
	1. Ventral	2. Dorsal	3. Middle	4. Cranial	5. Caudal	6. Middle	7. Cranial	8. Caudal	$\frac{2\times 100}{1}$	$\frac{3\times 100}{6}$
Montardit I	(11.0)	12.0	9.0	(16.0)	16.0	15.0	17.0	16.0	109.09	60.00
4 Ofnet	11.0	13.0	10.0	15.0	16.0	15.0	20.5	21.0	118.18	66.67
6 Ofnet	10.5	11.0	8.5	13.5	15.0	14.5	20.0	19.0	104.76	58.62
Chancelade	12.0	14.5	..	..	...	..	..	..	120.84	—
20 Europeans[1]	14.7	..	..	..	..	..	..	..	.....	....

IV CERVICAL

	1. Ventral	2. Dorsal	3. Middle	4. Cranial	5. Caudal	6. Middle	7. Cranial	8. Caudal	$\frac{2\times 100}{1}$	$\frac{3\times 100}{6}$
Montardit I	11.0	(10.0)	9.0	18.0	16.0	—	—	—	110.00	....
3 Ofnet	12.0	12.0	10.5	15.5	15.0	14.0	23.0	22.5	100.00	75.00
5 Ofnet	10.5	10.5	8.5	13.0	14.0	13.5	19.5	19.0	100.00	62.96
20 Europeans	14.7	—	—	—	—	—	—	—	.....	....

DORSAL

First

	Height Ventral	Height Dorsal
Montardit I	14.0	17.0
Chancelade	16.0	20.0
20 Europeans	15.2	—
20 ♂ Japanese[1]	15.7	—

Tenth

	Height Ventral	Height Dorsal
Montardit I	21.0	—
20 Europeans	23.2	—
20 Japanese	21.5	—

Eleventh

	Height Ventral	Height Dorsal
Montardit I	23.0	25.0
Chancelade	21.5	25.0
20 Europeans	24.5	—
20 ♂ Japanese	22.1	—

[1] Martin, *Lehrbuch*, p. 960.

The greatest thickness is the same as that of modern Europeans and in contrast to the broad, thick bone of the Chancelade skeleton.

Footbones. With both Azilian skeletons, a small number of footbones remained intact. Unfortunately, the selection in few instances was identical, so almost no comparison is possible. The calcanea of Montardit I have a maximum length of 79 mm., which coincides with Southwestern Indian groups measured by Hrdlička. For 55 United States Whites the mean is 83.3 mm., and the heel of the fossil skeleton of Chancelade, of stature slightly less than Montardit, has a length of 87 mm., while three Cro-Magnons from Grimaldi range from 88–97 mm. The Montardit calcanea exhibit

Table 2. Right Patella Male

	Height Maximum	Breadth Maximum	Index	Thickness
Montardit II	42.0	44.0	104.7	19.0
3 Cro-Magnon, Mentone	47.0	50.0	105.8	?
Chancelade	44.0	52.0	118.2	25.0
8 Munsee Indians [1]	45.0	46.0	102.8	21.0
100 United States Whites [1]	45.6	46.0	101.7	21.0
Europeans (Martin)	41.2	42.4	102.9	19.3

no torsion. Three facets for the astragalus are present, a condition which Hrdlička found in 74 per cent of 125 Whites and Indians. This is also true of the Chancelade os calcis.

A first metatarsal was present in both skeletons, Montardit I, left, Montardit II, right; lengths 58 mm. and 63 mm. The right bone from Chancelade measures 64 mm. Means for males given by Martin are as follows: Europeans 60.2 mm.; Japanese 54.4 mm.; Hottentots 53 mm.; by Hrdlička (both sexes): Munsee Indians 63 mm.; United States Whites 66 mm.

Montardit II still retained a left scaphoid and a right cuboid and internal cuneiform. The measurements of these, together with those of the Chancelade skeleton and the means for Whites and Indians, show the same tendency noted in the other footbones to be always slightly smaller than the Indian, but nearer to them than to the other figures.

[1] Hrdlička, *Physical Anthropology of the Lenapé.*

Table 3. Tarsus

Left Scaphoid, Male

	Breadth Maximum	Height	Stoutness	Height-Breadth Index	Stoutness-Breadth Index
Montardit II	39.0	20.5	27.0	52.6	69.23
Chancelade	43.0	20.0	?	46.5	?
Munsee	41.3	20.8	25.9	50.4	62.8
United States Whites	43.3	22.3	29.6	51.5	68.5

Right Cuboid, Male

	Length	Breadth	Thickness	Breadth-Length Index	Thickness-Length Index
Montardit I	38.0	29.0	23.0	76.3	60.5
Chancelade	42.5	30.0	25.0	70.6	58.8
Munsee	37.5	28.5	25.2	75.8	67.1
United States Whites	39.6	30.2	25.9	76.3	65.5

Right Internal Cuneiform, Male

	Breadth	Height	Breadth-Height Index
Montardit II	22.0	34.0	64.7
Chancelade	?	37.0	?
Munsee	22.4	31.7	70.7
United States Whites	24.3	34.8	69.9

The remaining footbones, fourth metatarsal right and left of Montardit II, had lengths of 64 mm. and 66 mm. The average for Europeans (Martin) is 66.7 mm.

Montardit I also still possessed the two third metacarpals, lengths 63 mm., corresponding with the European mean cited by Martin of 62.8 mm.

PATHOLOGY

Abscesses and inflammatory disease have left traces in three regions of the Montardit skeleton: alveolar borders, the vertebrae, and the shaft of the left ulna. Such a condition as has already been described in the molar region of maxilla and mandible must have sent out a septic stream to all parts of the body which may well account for the state of the ulna. Below the nutrient foramen and extending downward for 29 mm., there is pronounced anterior bulging of the shaft, and nearer the extremity a second bulge of less circumference and of 26 mm. in length. The slight displacement and obvious absence of shortening in comparison with the normal right bone rules out the possibility of a double fracture. Nor does the region suggest arthritis. Lues, favorite speculation of palaeopathologists, would be hard to prove, particularly since no lesions appear on skull or long bones. Roentgenograms may shed some light on the cause, but for the moment, at least, it is safest to leave it at disease, ostitis; cause, possibly teeth (Plate 6).

In the three upper regions of the vertebral column, pathological changes are evident. All of the vertebrae are very light, and many centra show age depression. On the third and fourth cervical, marked depressions are associated with marginal exostoses of arthritic type; slight exostoses are also present on the bodies of two dorsal vertebrae, and in the lumbar region age and arthritis have combined in destruction. The cranial surface of the third lumbar vertebra is depressed at the center and a rough exostosis edges the upper ventral border. The centrum of the fourth is intact, but a pronounced exostosis follows the entire lower ventral border. It is in the fifth, however, that the disease is most advanced (Plate 7). The upper surface of the bone has been eaten away anteriorly almost to the inferior surface. The lower face of the centrum is normal in appearance, but exostoses of exceptional size protrude from both borders. At the margin of the inferior surface, this bony outgrowth is 9 mm. thick at the center and extends 7 mm. below the surface of the body. It is this exuberant growth of bone which indicates *arthritis deformans* rather than *spondylitis tuberculosa* which the condition of the centra might otherwise suggest. Bartels [1] has described a case of vertebral caries, probably tubercular, from the Neolithic period. The fourth, fifth, and sixth dorsals were coalesced and the bodies greatly reduced. No other signs of malady appeared on long bones or articulations, and no lesions on the skull. The chief interest, the author states, is this evidence of the great age of the disease, the oldest case previously cited being from the Merovingian period.

This same factor, the ancient origin of disease, again confronts us in the much older remains from Montardit. And at this far-off moment, the exact nature of that malady and its interrelation with age, arthritis, and alveolar abscesses it is safer to speculate upon than to state.

[1] *Archiv für Ant.*, vol. VI (1907), pp. 243–255.

MORPHOLOGICAL RATING

From time to time in the descriptive notes of the Azilian skeleton, we have spoken of characteristics showing degrees of development differing widely in the evolutionary scale. Thus we have in the lower jaw the typical apelike smoothness of the mylo-hyoid region associated with genial tubercles of ultra-human type, and an extreme condition of the sharp European shin-crest together with primitive "squatting facets" and retroversion of the tibial head.

This tendency to inequality in morphological traits, not only in such striking cases as the Piltdown jaw and cranium, and the brain-case and femur of Pithecanthropus erectus, but also in all modern types of man, has recently been brought forward by Professor Earnest A. Hooton of Harvard University. In order to demonstrate the essentially asymmetrical character of human evo-

Table 4. Mean Ratings of Crania

(Hooton)

	Brain Case	Face	Total	Standard Deviation
Gorilla, male	1.33	1.65	1.51	0.59
Orang-utan, male	1.77	1.52	1.68	0.90
Gorilla, female	1.89	2.00	1.95	0.66
Orang-utan, female	2.27	1.74	1.98	0.81
Chimpanzee, male	2.00	2.13	2.07	0.64
Pithecanthropus	2.64	—	2.64	0.77
Heidelberg	—	2.70	2.70	0.83
Broken Hill	3.05	3.86	3.46	1.00
Piltdown	4.31	2.30	3.63	1.17
Neanderthal	3.47	3.74	3.63	0.89
Talgai	4.00	3.65	3.81	0.88
Eskimo	4.16	3.91	4.00	0.96
Australian	3.83	4.30	4.10	0.65
Combe Capelle	4.39	4.13	4.24	0.88
Negro	4.50	4.22	4.34	0.65
Montardit[1]	4.92	4.56	4.71	0.88
Mongol	4.94	4.43	4.71	0.67
Guanche	4.89	4.78	4.83	0.69
Mediterranean	5.22	5.00	5.10	0.93
Nordic	5.33	5.09	5.20	0.96
Alpine	5.61	4.96	5.24	0.69

[1] This memoir.

lution, he has devised a scheme of morphological rating [1] whereby the cranial characters of the apes and all types of man can be evaluated in terms of lagging or progression. For each trait, there are six degrees of development from ultra-anthropoid to ultra-human.

Table 5. Morphological Rating of Montardit I

(Hooton Scale)

Frontal Region	
Brow-ridges	4
Elevation	5
Slope	5
Postorbital constriction	5
Breadth	5
Sagittal Region	
Breadth	4
Crest, elevation	6
Temporal Region	
Supra-mastoid crest	4
Fullness	5
Mastoids	6
Occipital Region	
Shape	4
Inion	6
Facial Region	
Orbits: inclination, proportion, shape	4
Lower borders of nasal aperture	4
Nasal spine	4
Nasion depression	4
Prognathism	
Alveolar	6
Palate	
Proportions	6
Shape	5
Mandible	
Size	5
Chin	5
Genial tubercles	6
Mylo-hyoid ridge	3
Breadth, ascending ramus	4
Teeth	
Canines, projection, diastema	5
Molars, proportion of crowns	5
Relative size of first and second molars	3
	Mean 4.71

[1] *Am. Jour. Phys. Anthrop.*, vol. VIII (1925), pp. 125–140.

1. Ultra-anthropoid; 2. Typically anthropoid; 3. Sub-human, supra-anthropoid; 4. Inferior human; 5. Typically human; 6. Ultra-human. The mean rating of crania with standard deviations is given below, with the addition of the Montardit skull.

With 28 of the 41 morphological characters present in the Azilian cranium, a fair rating was obtainable in the following manner.

The total mean of these 28 characters, 4.71, somewhat more than halfway between the inferior human and typically human groups, is higher than for any fossil skull rated by Hooton. It is almost identical with the Mongol on his scale. Rated separately, the brain-case shows itself to be both more highly evolved and less variable than the facial region, brain-case 4.92 ± 0.76; facial region 4.56 ± 0.93. It is in the mandible of the man of Montardit that the only two features rated less than inferior human (4) occur.

In 13 out of 19 types, the brain-case is the more highly evolved region, this being uniformly true of the eight highest means (including Montardit). The orang-utan, both male and female, the Piltdown and Talgai skulls, and Eskimo crania follow the same rule. But Neanderthal man, the Broken Hill skull, the modern Australian, together with gorilla and chimpanzee, have developed in the opposite manner, the evolution of the brain-case not keeping pace with the reduction of primitive features in the face and jaws.

COMPARATIVE DATA

There can be little scientific satisfaction in drawing conclusions as to race type from a solitary specimen, nor can the fairly amusing game of minute comparisons with isolated individuals from other epochs lead to brilliant discoveries. But until some ninety-nine additional men who inhabited the Pyrenees during the Azilian culture period are unearthed, we simply put on record the unreliable first, and wait hopefully for more. In the meantime, such comparisons as the Montardit material warrants have been drawn with late palaeolithic predecessors, together with a more detailed study of possible relationship to human remains from other Azilio-Tardenoisian sites.

I. UPPER PALAEOLITHIC

The three types of fossil men associated with Aurignacian and Magdalenian cultures selected for comparison with the Montardit burials are the Cro-Magnon peoples, the Chancelade skeleton, and the more recent finds at Solutré. The position of the Montardit man in the evolutionary scale rules out the necessity of seeking kinship to the Neanderthal race, and the common possession of traits more or less primitive but typically human within these later groups makes generalized kinship obvious.

From the Cro-Magnon as represented by the three individuals from the type site and the five males from the caves of Mentone, the Montardit skull differs obviously in capacity and proportions. It is shorter by 22 mm. and with a cubic volume, according to the Pearson formula 10*bis*, of more than 300 c.c. under that for the Old Man of Cro-Magnon. Whereas all the specimens cited above are distinctly dolichocephalic, the Azilian index reaches mesocephaly. The author, through the great courtesy of Professor Verneau, was privileged to examine the three crania from Cro-Magnon and to make the morphological observations tabulated below.

Evidently, with these pronounced types which gave rise to the belief in the homogeneity of a tall, dolichocephalic, disharmonic Aurignacian race, the Montardit skull has little in common, but within a group which may include such aberrant individuals as the small brachycephalic female from Le Placard, and during an era which we now know saw the high, sub-brachycephals of Solutré

Montardit I	Cro-Magnon I, II, III
Norma lateralis	
Simple curve, reaching greatest height, ca.25 mm. before obelion. Moderate flattening between obelion and lambda.	I, II, and III all show frontal rising to bregma, post-coronoid depression and continuation of curve.
Occiput	
Convex. No protuberance. Inion small but clearly marked.	Flattened in the lambdoid region and extremely protuberant. Torus large.
Temporal bosses	
Non-salient.	Low and outstanding.
N.B. Supra-mastoid crests as large as C-M I. Mastoids size of ♀ C-M II	
Brow-ridges	
Pronounced development not only in sinus region but extending to and associated with great thickening of orbital border.	Pronounced over region of frontal sinus, then disappear. (C-M I and III, and Verneau's observations for Grimaldi.)
Orbits	
Shorter and a bit higher than C-M.	Very long and low.
Mandible	
Slender.	Heavy. Ascending ramus wide.
Eversion of gonial angles.	
Chin — oval.	Chin — triangular.

well established in France, there is the possibility of finding closer kinship.

In comparison with the most complete Cro-Magnon under our observation (the "Old Man"), one region of the Montardit calvarium showed distinctly greater development — the portion of the vault between bregma and lambda. The arc between these points measured 130 mm. alike for Cro-Magnon I and the two small Montardit skulls, and the diameter only 5 mm. less than Montardit I and 2 mm. less than Montardit II, whereas the difference between the glabello-occipital lengths of Cro-Magnon I and Montardit I is 22 mm. The diameter bregma-lambda of the Montardit is 64% of the glabello-occipital; the Cro-Magnon 59.9. Associated with this is an auricular-bregma height — maximum length index of 61.4 for Cro-Magnon in contrast to 65 for Montardit.

The difference in the low stature of the Azilian man and the high Cro-Magnon mean[1] is outstanding, but in type and stage of devel-

[1] 5 ♂ from Grimaldi 182 (Tables of Manouvrier); Old Man of Cro-Magnon 177.

opment, the limb bones in the Musée d'Histoire Naturelle de Paris conform closely to those of the small successor. The Cro-Magnon femur is less curved, the angle of the neck less open, the torsion of the head more pronounced, but the pilaster, the linea aspera, and the development of the sub-trochanteric region while evidencing heavier musculature are of the same primitive human variety. The maximum diameter of the head, 48 mm., is almost equalled by the Azilian bone, 47 mm. The tibiae of both specimens have a pronounced backward inclination of the head, but the Cro-Magnon shin crest is relatively indistinct in contrast to the sharpness of Montardit I.

In two features in which it differs widely from the Cro-Magnon type, the Montardit Azilian most nearly approaches the Magdalenian man of Chancelade. Both were short; both were hypsicephalic, and in degree the honors were divided. The Chancelade man is the shorter by 21 mm. (Pearson formula) and Montardit I has length-auricular height index higher by 2 points. Such limb bones as can be compared are of nearly equal length; — femur, maximum, Montardit 407 mm.; Chancelade 408 mm.; ulna, 252 mm. and 255 mm. The upper arm of the Magdalenian was probably longer, the humerus measuring 300 mm., while the bone of the Montardit man could not have been much over 280 mm. Testut,[1] comparing his subject with means derived from ten European males, finds the humerus massive in relation to its length, with an "*indice de largeur*" of 88. The European mean is 69, so that of Montardit (75) is also relatively robust. With its greater length and breadth, however, the Chancelade arm bone has a smaller head; diameter 39.5 mm., Montardit 44 mm. Measurements of the clavicle indicate a man of broader build than the two Azilians; the length maximum of 148 mm. surpasses the Montardit collar bones by 8 mm. The middle diameters of all three are nearly identical. Testut's description of the Chancelade clavicle, distinguished by "sa gracilité et degré de courbure," is equally appropriate to Montardit I. The general characteristics of the leg bones — femora slightly curved, with pilaster and sub-trochanteric fossa; tibial heads distinctly retroverted — conform to the primitive pattern of Cro-Magnon and Montardit. The unusual size of the Chancelade feet have already been noted in the description of the Montardit tarsus.

[1] *Bull. Soc. d'Anth. de Lyon*, vol. VIII, pp. 131–246.

When we consider the cranial characters of the Magdalenian, aside from the length-height relation, we find little in common. The Chancelade skull is large, distinctly dolichocephalic (index 72), and even after the Testut capacity of 1710 c.c. (taken with mustard seed) shrinks by the Lee-Pearson computation to 1532 c.c.; the brain size contrasts all too favorably with the little man of Montardit. Moreover, it is in just those peculiarly Eskimoid traits which distinguish the Chancelade skull that the Azilian is wholly lacking. Of the four characters which Hooton[1] names as distinctively Eskimoid, mandibular and palatine torus, thickness of tympanic plate, and scaphoid vault, the first two are prominent in the Chancelade skull and totally absent in the Montardit mouth, while the small median elevation of the frontal bone has no continuation in the sagittal region, no hint of the typically Eskimoid ridge so marked on the Chancelade vault. As for the thickness of the tympanic plate, this could not be measured on the Magdalenian specimen as only a cast was available, but the Montardit maximum thickness of 4 mm. compared to various averages (Eskimo 6 mm., Icelanders 5 mm., Italians 4.5 mm., Southern California Indians 4 mm.) seems as far removed as the other three traits from the conditions hereditary or functional which gave the Chancelade cranium its characteristic form.

From these two palaeolithic types with which, in their distinctive features at least, the Montardit Azilian has little in common, we now turn to a group which illustrates the variety and complexity of human types at a period earlier than was once believed. The skulls excavated from Aurignacian strata at Solutré during the seasons 1923 and 1924, while retaining various Cro-Magnon features such as outstanding parietal bosses contributing to the well-known pentagonoid form, faces short and very broad and long low orbits, are by no means so disharmonic. These are much shorter skulls with cephalic indices ranging from 78 to 83, justifying the conclusion that "la dolicocephalie des Paléolithiques ne doit plus être considerée comme un dogme absolu."[2] Also in contrast to the Cro-Magnon type, these are hypsicephalic crania with auricular height-length indices of 68 and 71, much higher than Montardit. Capacities, while somewhat below many of the Cro-

[1] *Am. Jour. Phys. Anthrop.*, vol. I, pp. 53–76.
[2] Arcelin et Mayet, Bulletin 2, *Assoc. Reg. de Paléont. Humaine*, Lyon (1924), p. 25.

Magnon figures, are still high, two males having cubic contents of 1515 c.c. and 1613 c.c.

The stature of these two, by the Pearson formula, is 171 cm. and 175 cm., while for a third 160 cm. to 170 cm. is given,[1] and a female was only about 154 cm. The long bones are robust, but lack the primitive features noted in all others previously described. No platymeria is present, no femoral pilaster, and in the subtrochanteric region there is no trace of fossa or third trochanter; the tibiae are very slightly platycnemic, and a tibio-femoral index of 79.9 is the same as Broca's mean for modern Europeans.

In relation to the Azilians of Montardit, this group from Solutré is significant, not because of many common traits, but rather for the proof they add of the complex heredity of man long before the end of the palaeolithic period.

II. MESOLITHIC

It is in the Azilio-Tardenoisian culture strata of western Europe that we find human remains near, not only in era and industry but in physical type as well, to the men of Montardit. If we disregard material from all sites of doubtful stratification, such as Furfooz and Sous-Sac (Ain),[2] we have, in addition to the fragmentary long bones from the Mas d'Azil, the Tardenoisian burials, representing nearly fifty individuals from the shell heaps of Mugem, Portugal, and the crania from the Bavarian sites of Ofnet and Kaufertsberg.

Of the arm and leg bones from the Mas d'Azil, mention has already been made in the discussion of the extremities and stature of Montardit I. Fragmentary as they are, their provenience justifies detailed examination. The type site of the Azilian culture, where the research of Edouard Piette upset all earlier beliefs in a complete hiatus between the Old and the New Stone Ages, is less than twenty miles from the *Trou Violet* of Montardit. There, in the stratum of painted pebbles, Piette found human remains which he described in a brief article.[3] "Les os longs avaient été mis en tas à côté de la machoire inférieure . . . . . tous rougis par du peroxide de fer — quelques-uns — rayés par le tranchant d'un

[1] Boule, *L'Anthropologie*, vol. xxxv, p. 188.
[2] Boule, *L'Anthropologie* (1904), "Mouvement scientifique."
[3] *Bull. de la Soc. d'Anth.* (1895), p. 485.

TABLE 6. MONTARDIT MEASUREMENTS COMPARED WITH MESOLITHIC AND PALAEOLITHIC MALE CRANIA

	Cranial Diameter 5								Orbit	Nose	Arcs	
	Glabello-Occipital	Inion	Lambda	Bregma Inion	Lambda	Lambda Inion	Breadth Maximum	Height Auricular	Height	Breadth	Total Circumference	Bregma Lambda
Montardit I	180	166	174	155	116	72	136.5	117	30	24	(510)	130
Montardit II	...	...	...	...	119	..	136	...	..	..	...	130
Kaufertsberg	182	175	179	...	115	58	141	117	29	26	511	129
4 Ofnet ♂	190.5	180.5	185	...	117	65	144	113.5	31	23	531	137
Mugem No. 6	185	...	...	...	...	..	136	...	31	21	505	...
Cro-Magnon I	202	196	195	158	121	63	149	124	27	23	568	130
Chancelade	193	190	(185)	(163)	(124)	(60)	139	(122)	34	26	538	(140)
Solutré 2	184	...	...	...	...	..	146	130	31	Lept.	...	...
Solutré 3	182	...	...	...	...	..	144	123	..	..	...	...

	Thickness of Vault			Indices		Capacity	Mandible		
	Left Parietal	Frontal at Bregma	Frontal 2.5 below Bregma	Cephalic	Auricular Height-Length	(Pearson (10 bis)	Symphysis Height	Ascending Ramus Breadth	Heigh
Montardit I	5.3	6	6	75.8	65.0	1389	31	32	53
Montardit II	3.6	9	10	...	...	....	..	..	..
Kaufertsberg	...	.	5.5	77.5	64.3	1432	35	34	63
4 Ofnet ♂	...	.	7	75.6	60.0	1461	33	37	61
Mugem No. 6	Considerable			73.0	...	(1370)	32	37	51
Cro-Magnon I	2.6	7	6	73.8	61.4	1702	37	42	(55)
Chancelade	...	.	.	72.0	63.2	1532	41	43	(62)
Solutré 2	...	.	.	79.3	70.6	1613	31	35	70
Solutré 3	...	.	.	79.1	67.6	1515	..	..	..

silex." A femur showed "une petite dépression triangulaire résultant d'une blessure faite par une flêche." The skull and all small bones, he reports, were missing.

Nothing in the burial customs here pictured suggests the Azilian graves at Montardit. In contrast to a heap of limb bones, the complete extended skeleton of Montardit I within its frame of stones showed no traces of scraping by flint knives or artificial coloration. On the bones of Montardit II as well, there were no marks to be unquestionably explained by other than natural causes. It was in morphology, then, rather than archaeology that analogies were to be sought. First of all, however, it was necessary to find the bones themselves. Thanks to the suggestions of Professor Boule and the kindness of various members of the staff of the prehistoric museum at St. Germain-en-Laye, the writer was able to measure and observe certain of these human fragments. In the Collection Piette at the Musée de St. Germain were found parts of two femora, a tibia, two humeri, a piece of a fibula and one of a right ulna. There was no sign of the mandible mentioned by Piette, but the provenience of these bones — "couche du galets, Mas d'Azil" — and the traces they bore both of red coloring matter and flint cuts, seemed to indicate their identity with the description above. Red color appeared along the pilaster ridges of the femora and on the tibia; scratches suggesting the use of flint knives were present on the neck of the left femur, and the right humerus showed many of these marks at the distal articulation.

In general, the character of the bones resembled the segments of the Montardit extremities. The femora — represented by the greater portion of the right diaphysis and the head and two-thirds of the left diaphysis — had marked pilasters, some platymeria, well developed lineae asperae, and pronounced sub-trochanteric fossae, all traits found in Montardit I. The diameter of the head, 38 mm., is appreciably smaller than that of the old Montardit male, and the diaphysis is more slender. The tibia from the Mas d'Azil, short, slender, and probably female (length ca. 307 mm., middle diameters 24 mm. and 17 mm., index 70.83), also exhibits characters prominent in Montardit I, particularly the extremely sharp shin crest associated with retroversion of the head. Of the two fragmentary humeri, the left shaft is bowed, the right straight; there was no bowing of either Montardit humerus. The bits of fibula and ulna from the Mas were deeply channelled and flattened; on the ulna, the line descending from the articular surface for the radius was very sharp.

A colored plate prepared for a monograph which Piette did not live to write reproduced a femur of life size with a maximum length of 447 mm. Calculations of stature from this and from the female tibia will be found in the section on Stature.[1]

From the Tardenoisian shell heaps of Mugem in Portugal comes evidence of another short mesolithic group. Near the bottom of a mound seven meters high were found remains of fifty individuals.[2] The accompanying fragments of animal bones, burned but not gnawed, included specimens of *cervus*, *ovus*, *equus*, *sus*, *canis*, *felis*, *meles*, *viverra*, *lepus*, and a few fish. Flint implements were scarce. Simple bone points, chips of stag horn, and an ornament made from a perforated pebble completed the industry.[3] No ochre was used in the burial rites and skeletons were found entire. The absence of these characteristics of Ofnet and Kaufertsberg suggests the Montardit graves. Few of the skeletons, however, were fully extended, the majority being tightly flexed.

By far the greater number of skulls were dolichocephalic; two were brachycephalic and one was sub-brachycephalic. Seven of the dolichocephals were measurable. They are described as "très homogènes." Long skulls are associated with long faces. Some prognathism, particularly sub-nasal, was present. The brow-ridges of the males were strongly developed. Cranial walls were thick and capacities small. Number 6, a male, of which Francisco Paula e Oliveira gives complete measurements,[4] is shown in Figure 1. Like Montardit I, this is a small skull with heavy brow-ridges and thick walls, accompanied by a mandible with marked eversion of the gonions. The maximum cranial breadths are nearly equal, but a greater length of 5 mm. in the Mugem male gives an index three points lower (73.0). The Montardit skull is the higher. Of the mandibular measurements, the heights of symphysis and ramus are close, but the Mugem ramus is broader than the very slender Montardit specimen. The cranial capacities were probably about equal. The figures given for Mugem 6 are approximately 1490 c.c. "par la méthode de l'indice cubique" and labelled "très peu

[1] See page 228. [2] Carthailac, *Les Ages préhistoriques de l'Espagne.*
[3] See Treat and Vaillant-Couturier for similar industry at Montardit.
[4] Carthailac, *op. cit.*

volumineux." The auricular height not being given, the writer used the Lee-Pearson formula 12 (method of least squares), which involves basion-bregma height. The result, 1408 c.c., is too large. The Kaufertsberg skull, soon to be described, with both these heights measurable had a capacity of 1473 c.c. by formula 12 and 1432 c.c. by formula 10 *bis* (see Table 6), an excess of about three per cent. The Mugem capacity, then, reduces to 1370 c.c., slightly smaller than that of Montardit.

In outline, the two skulls show certain differences. The alveolar prognathism of the Mugem skull has been mentioned. The

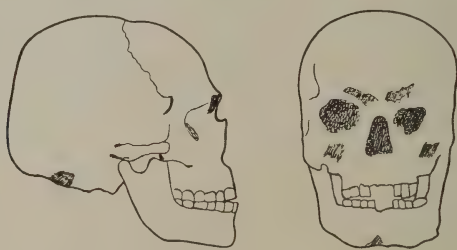

FIGURE 1
Male cranium from Mugem
(after Carthailac)

parietal flattening above lambda characteristic of both Montardit profiles seems to extend well down the Mugem occiput; the lower vault also contributes to the deviations. But in the interrelationship of small size and great muscularity, and in total absence of Cro-Magnon outlines and disharmony, the total impression is of similarity, if not of the closest kinship.

The stature of the Montardit Azilians and the Mugem Tardenoisians contributes to this common picture and has already been mentioned. The mean statures for 7 males from Mugem calculated from all possible long bones was 156.0 cm. by the Manouvrier tables and 157.5 cm. by the Pearsonian method. Montardit I had a stature of 159.8 cm. The Mugem range was from 154.1 cm. to 159.8 cm. Only bones of the upper extremity were available for the calculation of female stature, so the two heights, 152.0 cm. and 147.8 cm., are not exactly comparable to the small, probably female stature of 145.0 cm. from the Mas d'Azil, which was based on a tibia. All, however, fall within the same group of remarkably low stature whose closest affinities among European racial groups are to certain neolithic peoples of France.

The most famous mesolithic site from the anthropologist's point of view, Ofnet in Bavaria, adds nothing to our knowledge of stature contemporary with the short men of the Portuguese coast and the French Pyrenees. Only skulls and cervical vertebrae were found in that spectacular group of twenty men, women, and children smeared with ochre and ornamented with shells and canine teeth. Several studies of the stratification, burial rites, and industry are well known, particularly those of Schmidt and Breuil. The similar setting for the individual from Kaufertsberg is less familiar. There also was found only the skull, with atlas and axis. They lay in red ochre. No ornaments were discovered, but the fauna and flint implements were clearly Azilian.[1] Secondary burial associated with the use of red ochre occurred in the Azilian layers of the Mas d'Azil, but seems to have included the entire skeleton,[2] while the simplicity of the Montardit and Mugem burials, flexed or extended, suggest a different cultural chain.

In physical characteristics, however, the closest kinship is between the Montardit crania, the Kaufertsberg skull, and one of the types from Ofnet. Fortunately, there is available for the study of these groups the exhaustive monograph by Dr. Walter Scheidt with its excellent photographs and life-size reproductions of drawings made by the Martin diagraph. Among the fourteen adults from Ofnet, Scheidt recognized five types of which the two extremes of dolichocephaly and brachycephaly he thinks show strong affiliations with Cro-Magnon and Grenelle. It is with type III represented by the Ofnet male skull 1800 and by the adult male from Kaufertsberg that we are chiefly concerned. Scheidt's description of these two crania follows:[3] medium size, muscular; mesocephalic; very high; oval in *norma verticalis*; moderately broad, well developed frontal region; uniformly developed parietal region with pre-lambdoid depression; occipital region symmetrical and non-protuberant; strong muscle relief; strongly marked glabella and supra-orbital ridges; mesognathous.

In addition to the striking similarity of this description, there is the frequent identity of measurements between Montardit I and

[1] F. Birkner, "Der Eiszeitmensch in Bayern," *Beitr. Anth.*, vol. XIX, Munich, 1914.
[2] No skulls were preserved, but Piette mentions the discovery of a mandible.
[3] W. Scheidt, *Die eiszeitlichen Schädelfunde aus der Grossen Ofnet*, p. 86.

Kaufertsberg (Table 6) and the striking number of common points in the superimposed profiles (Fig. 2.) The four measurements of the axis, the only instance of the same vertebra found with both skulls, all indicate a more robust development in the Montardit specimen (Table 1).

That trait in which the Kaufertsberg skull differs most widely from Ofnet 1800 is the narrowness of the face. Unfortunately, this

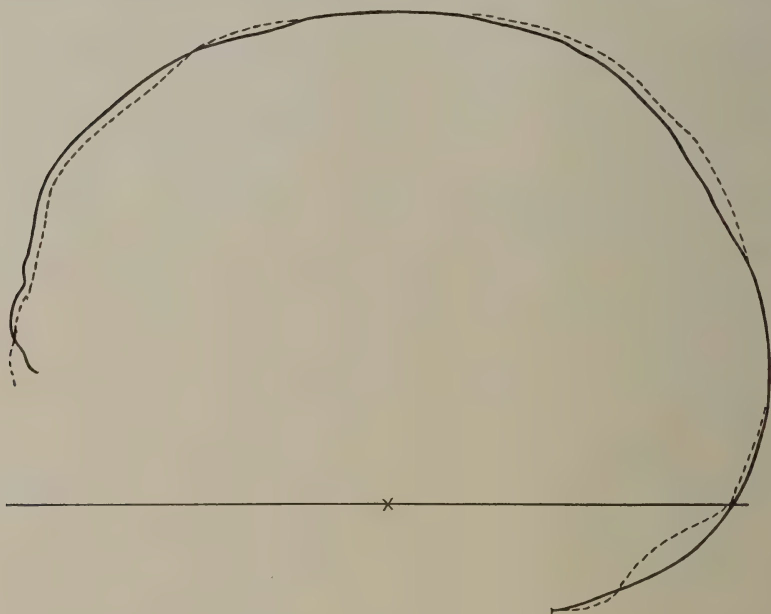

FIGURE 2

Superimposition of sagittal arcs of Montardit I and Kaufertsberg skulls
Montardit I ——. Kaufertsberg - - - - -. Life size

region was too fragmentary in the Montardit cranium for either measurement or speculation. Scheidt stresses the potential significance of this facial form in a discussion of the possible origins of the Ofnet-Kaufertsberg group.[1] Between the two, he finds only a moderate racial affinity. The Ofnet group, however, contains such extreme forms as the low dolichocephalic Cro-Magnon type and the extremely brachycephalic of Grenelle, and the divergence of the Kaufertsberg skull from its nearest affinity at Ofnet is not

[1] *Der nacheiszeitliche Schädelfunde vom Kaufertsberg.*

so great as the five Ofnet types from one another. The Azilian period was a time of mixing of types very far apart, and the narrow face of Kaufertsberg may be considered either as a new, not yet known racial element, or as the result of racial crossing.

Further evidence to strengthen Dr. Scheidt's conception of the Azilian as an age of racial mixture is certainly present in the association of long and short skulls at Mugem. All these skulls were small and all the long bones indicated low stature. It would be of inestimable value to know the stature of Ofnet 1818, the "Cro-Magnon" male with a glabello-occipital diameter of 205 mm., and that of the two males so closely resembling Montardit I. Racial origins and racial affinities can never be based on the skull alone. At Ofnet, the individual nearest to Montardit I was an intermediate type. We cannot be sure, however, that he represented a mixture of the two extremes also present, nor can we definitely associate him by analogy with the descendant of the most specialized palaeolithic peoples and the forerunner of a prominent neolithic type who was buried in the *Trou Violet* at Montardit.

Mixture undoubtedly did take place in the Azilian period, and doubtless much earlier. Or new forms other than those once believed peculiar to the pre-neolithic may then have put in a European appearance. Certainly the skulls from Solutré bear evidences of types far from classical before the Aurignacian ended.

SUMMARY

The remains of the two Azilians found in the *Trou Violet* at Montardit in the French Pyrenees, so far as the few traits preserved in common are concerned, seem homogeneous in type. This judgment rests largely on the parietal region and on the thickness and muscularity of both skulls.

The almost complete skeleton, Montardit I, an old male, was of short stature (159.8 cm.). The bones of the extremities show various traits primitive as opposed to modern European but in no way suggesting anthropoid characters. The degree of development of the cranium can be similarly placed. Small, with heavy brow-ridges and mastoids, non-prognathous, mesocephalic, hypsicephalic, and with several contradictory features in the mandible, its final rating on the Hooton evolutionary scale is identical with the modern Mongol and surpassed only by Mediterranean, Nordic, and Alpine.

Certain abnormalities of maxilla, ulna, and vertebrae caused by age and disease add further items to the lists of palaeopathology.

The racial affiliations of the Montardit people seem to lie not in the groups of the Upper Palaeolithic but in the Azilo-Tardenoisian types of France, Portugal, and Bavaria. Low stature is common to Montardit, the Mas d'Azil, and Mugem. There are similarities between Montardit and Mugem skulls, and between Scheidt's Type III Ofnet-Kaufertsberg crania and the skull of Montardit I a large number of traits are identical.

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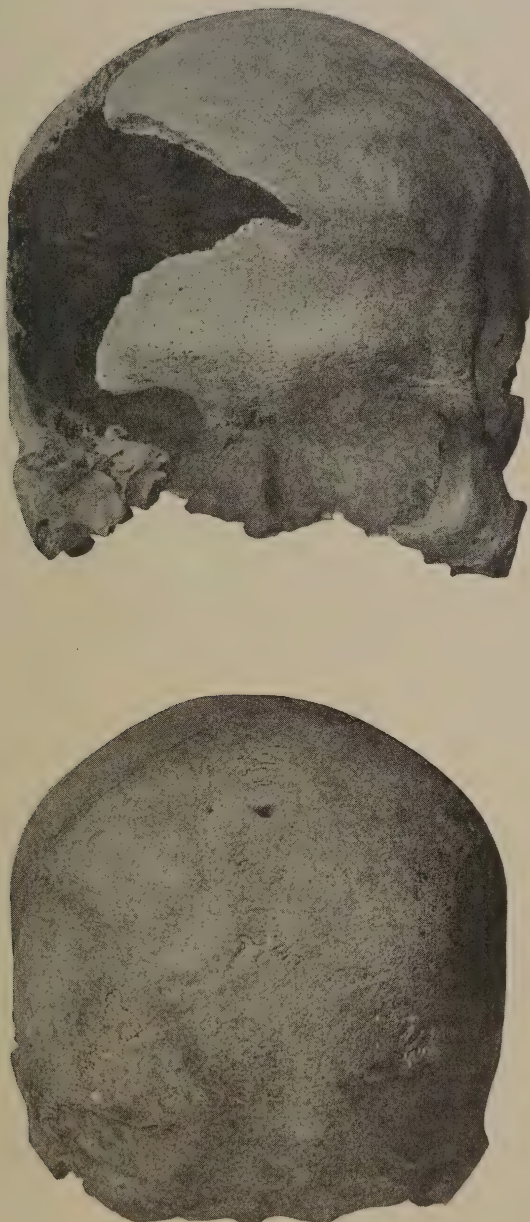
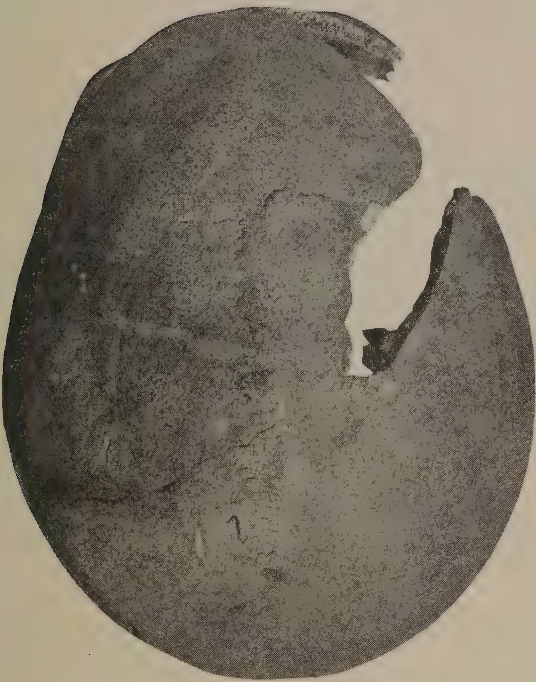
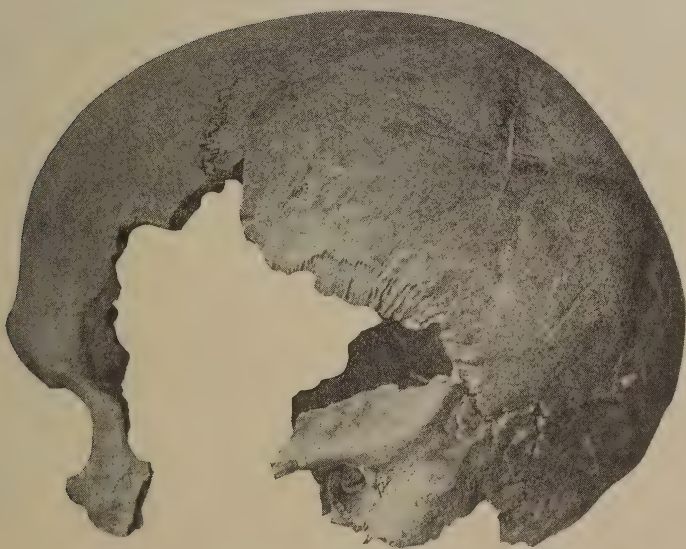
PLATE 1



Cranium of Montardit I, *Norma frontalis* and *Norma occipitalis*





Cranium of Montardit I, *Norma verticalis* and *Norma lateralis*

Maxilla of Montardit I

PLATE 4

Mandible of Montardit I

Right femur and right tibia of Montardit I, lateral and anterior views

Right and left ulnae of Montardit I, anterior and lateral views

Fourth lumbar vertebra of Montardit I

PAPERS

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THE EVOLUTION OF THE HUMAN PELVIS IN RELATION TO THE MECHANICS OF THE ERECT POSTURE

BY

EDWARD REYNOLDS

THREE PLATES AND TEN ILLUSTRATIONS IN THE TEXT

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CONTENTS

LIST OF ILLUSTRATIONS

Plates

Figures

THE EVOLUTION OF THE HUMAN PELVIS IN ITS RELATION TO THE MECHANICS OF THE ERECT POSTURE

INTRODUCTION

Few subjects in physical anthropology have excited more interest than the development of the specializations which enable man to maintain his erect posture and the bipedal activity by which he is distinguished from all other mammals. Among the many specializations which have a bearing upon this subject two are of predominant importance. Those of his very distinctive foot have been extensively studied, while the characters which distinguish his equally unique pelvis have received but little attention. The method by which these peculiarities have been developed, under the operation of the fundamental mechanical laws, and their functional relation to the mechanics of the erect posture will be discussed in this paper along the following lines:

THESIS

A study of the primitive characters in the mammalian pelvis and a description of the writer's method of tracing the development of the various specializations which are necessary to the varying habits of the more highly specialized groups.

A brief reference to the simple laws of balance in their bearing upon the feet as the base of support and upon the pelvis as the main factor in stabilizing the attitude.

The quadrupedal position of the femur in its relation to the pelvic shape and architecture, contrasted with its position in erect man and its mechanical relation to his pelvis.

The animals which make at least an occasional use of at least a partially erect posture, and which exhibit in their pelvic development transitional stages between the most generalized quadrupeds and highly specialized man, are the marsupial kangaroos (*Macropodidae*); the edentate anteaters (*Myrmecophagidae*); many small animals, principally rodents, which have well developed erect sitting habits; the bears (*Ursidae*), which are Carnivora; the lower Primates; and the anthropoid apes. The habits and skeletal development of each of these must be discussed in some detail.

The human pelvis and the bipedal activities of man.

The ilia of the ungulates and of Bradypus will be discussed in an appendix.

LAW OF SQUARES AND CUBES

A mechanical principle which should always be remembered is that if the shape and proportions of any material body remain the same, but its size varies, its strength increases as the square of any one dimension, while its weight increases as the cube.

This law is of universal application, and applies not only to every structure of mechanical function, but to every part of such a structure; animate or inanimate. It applies then, not only to a complete animal, but to every individual bone and muscle in that animal. We shall readily see that it is of fundamental importance in every skeletal specialization which we encounter.

Consider as an illustration the case of a simple and generalized mammalian species, which in the course of its evolution gradually increases in size. Suppose for a moment that in its increase from a total length of two inches to one of four inches it underwent no other change, and consider the consequences which would ensue. During this growth its length has been multiplied by two; its weight will have increased as the cube of two, and it will then weigh eight times as much; but the strength of its muscles will have increased merely as the square of two, and it will be only four times as strong.[1]

It will then be endeavoring to move eight times its original weight by muscles only four times as strong. It is evident that it would fail in the competition of life. With no great further increase of size, it would indeed become incapable of motion.

It might seem that the difficulty could be met by a greater and disproportionate increase in the size of the muscles, but this would

[1] A muscle is made up of many fusiform cells of a given size, arranged essentially side by side, and connected essentially end to end; each is capable of a given amount and of a given strength of contraction. The strength of a muscle is then proportionate to the number of cells arranged side by side in its cross section, i.e. to the square of its diameter, while its length, i.e. the number of cells which are connected end to end, determines only the length of its contraction.

at once result in a further and still more disastrous gain in weight. It is then evident that in the evolution of greater size an increase of muscular strength appropriate to the much greater increase of weight must be attained in some way which does not involve a further increase of weight. As a matter of fact, it is usually obtained by changes in the bones and muscular attachments that improve the leverages afforded to the muscles and so give them increased power without disproportionate increase of weight.

CONSEQUENCES

The strength of the bones which are to be moved must, moreover, be proportionate to the power of the muscles which are to move them, and here again, if the animal is to maintain its activity, the increased strength of bone must be obtained without a disproportionate increase of weight. This can only be obtained by improvements in their internal construction.

As soon as the skeletons of the mammalian series are studied from a mechanical standpoint it is at once plain that this apparently difficult problem has been solved by the evolutionary forces in a manner which is of necessity in strict accordance with those fundamental mechanical laws, by the discovery of which, and in obedience to which, the human engineer has learned to carry on his work.

The necessary increase of power has been provided without disproportionate increase of weight by the appearance of processes [1] which give to the muscles attached to them improved leverages which yield the required gains in power without any significant further increase in the size or weight of the muscles.

Examples of such increase of power by improved leverage, in fact, appear on every hand as we follow the bones of the mammalian series from the simpler to the more specialized groups.

The increased strength of the bones which enables them to resist this greater power must also be obtained without undue increase in their weight. This is, in fact, afforded to them by improvements in their internal architecture, which are again in strict accordance with well-known and fundamental mechanical principles.

1 Or other changes in the shape of the bones.

It is a matter of common knowledge that a tube of given weight is stronger than a rod of the same weight and which contains the same amount of substance. The first change to be noticed in this study is the replacement of the simple rod construction of the most primitive bones by the tubular long bones of most mammals.

It is well known that the strains and stresses imposed upon a rod are greatest at the surface and least at the center. Under the operation of evolutionary law, the tubular structure of the long bones has then resulted from hypertrophy at the surface and atrophy at the center. The process of gain in strength without increase of weight does not, however, stop here. The strength of a tube can, of course, be greatly increased by cross bracings within its lumen, and nothing would please the human engineer more than to lighten his tubular construction by carrying such cross bracing to its logical extreme, if this were not inhibited by the nature and cost of his materials and labor. The forces of evolution have proved quite able to carry this process to what appears to be at least a close approach to perfection.

The arrangement of the spiculae of solid bone and of the cancellated tissue which cross braces and supports them within the trochanteric angle of the femur is a beautiful instance of the accuracy with which this law produces just the arrangements which are indicated by mathematical computation for such an L-shaped supporting structure,[1] and the resistance of the pelvis to great strains, in spite of its light weight, is another excellent example.

The appearance of increased power without disproportionate gain in weight is not, however, merely a necessary element in the development of giantism, and as such, apparent in every portion of an animal whose species has increased in size. It is also an almost equally necessary element in the development of most, if not all specializations, and may therefore be present in marked degree in some one part only of an individual animal.

In point of fact, whenever a given species has acquired specialized habits, the conditions which give increase of muscular power and strength of bone will be especially well developed in those parts of its body on which the specialized habits impose especial demands.

1 Gray, 1893, *Anatomy*, p. 248.

Familiarity with these two mechanical advances will prove to be of importance to every step in this study of the development of the pelvis, and several of the corollaries which follow from it are also so important that it may perhaps be advantageous to enumerate them here, before proceeding to the detailed study of their results.

Large and heavy species usually show any given specializations in higher degree than their relatives of similar habits but of lesser weight.

Increased activity has the same effect as increased weight, because a quick start against the inertia of a stationary body requires much more power than the maintenance of motion after it has been inaugurated, a fact familiar to everyone who has ever driven an automobile.

Economy of weight at every point is an element of primary importance in the evolution of an active and efficient species. The great importance of this fact is seldom sufficiently appreciated.

Since the disadvantages which result from increased weight under the law of squares and cubes can rarely be completely compensated, the smaller animals are usually the more active.

With these mechanical principles well in mind, we may proceed to the consideration of the primitive forms of pelvis from which we are to trace the development of the highly specialized girdle of erect bipedal man.

THE PRIMITIVE PELVIS

Some idea of the probable pelvis of the primitive ancestral mammals may be obtained by assembling the characters which are common to all mammalian pelves, and by eliminating those which are present only in groups which have become specialized in some given direction.

Such a conception can then be checked by comparing the hypothetical pelvis so constructed with the least specialized pelves which can be found in each of the several mammalian orders.

Figure 1 shows outlines drawn by camera lucida from such a group. It depicts a specimen from each of the mammalian orders with four exceptions; the Sirenia, Cetacea, Ungulata, and Chiroptera.[1]

Each of these pelves is from a family or genus of generalized habits and structure, and was selected from among those groups as representing the species which showed the least degree of the specializations characteristic of the order.

All of even these pelves show some degree of specialization, and at first sight one is impressed chiefly by their differences, but on analysis their striking similarity in fundamentals becomes apparent.

Their somewhat close resemblance in general shape should be noticed before proceeding to a detailed discussion of their several parts.

COMMON CHARACTERISTICS

In all of them, the ilio-ischiatic length exceeds the bilateral width (as a rule, by about two to one), while externally, the dorsoventral depth at the acetabular level is always less than the greatest width. (See Table 1.) The cavity of the true pelvis is, however, in all these instances, pentagonal in shape and with the sagittal diameter greater than the transverse. (See Table 2.)

[1] The vestigial pelves of the Sirenia and Cetacea are not without interest in the reconstruction of the primitive pelvis, but are omitted here, as having no direct bearing upon our special subject. The orders Ungulata and Chiroptera are highly specialized throughout, and contain no unspecialized or primitive pelves. Each of the other orders is represented.

TABLE 1. LENGTH AND BREADTH DIAMETERS AND INDICES OF PRIMITIVE PELVES

THE LENGTH ALWAYS EXCEEDS THE BREADTH

	Length	*Breadth*	*Index*	*Average Index*
Zaglossus (2)	8.1	3.9	48.15	
	10.5	5.4	51.43	49.79
Didelphis (3)	7.9	3.8	48.10	
	7.3	3.2	43.84	
	7.8	3.4	43.59	45.18
Genetta (2)	6.4	3.3	51.56	
	6.3	3.3	52.38	51.97
Manis (3)	13.4	11.1	82.84	
	8.3	6.3	75.90	
	5.0	3.9	78.00	78.91
Marmota (4)	7.5	3.9	52.00	
	7.4	5.2	70.27	
	7.4	5.2	70.27	
	7.7	5.2	67.53	65.02
Tupaia (1)	2.6	1.7	65.38	65.38
Lemur Mongos (1)	4.8	7.5	64.00	64.00

Many more specimens of these pelves were studied, but for the purposes of this and the two succeeding tables the few which were readily at hand were thought sufficient, since the indices are so very distinctive.

TABLE 2. INTERNAL DEPTH-BREADTH DIAMETERS AND INDICES OF PRIMITIVE PELVES

	Sagittal	*Transverse*	*Index*	*Average Index*
Zaglossus (2)	4.0	2.4	60.00	
	5.7	3.5	61.40	60.70
Didelphis (3)	4.7	2.6	55.32	
	3.5	2.2	62.86	
	4.7	2.6	55.32	57.83
Genetta (2)	3.0	2.3	76.67	
	3.0	2.3	76.67	76.67
Manis (3)	7.1	4.5	63.38	
	5.3	3.7	69.81	
	3.2	2.5	78.12	70.44
Marmota (4)	4.1	2.3	56.10	
	4.0	2.1	52.50	
	3.9	2.1	53.85	
	4.4	2.2	50.00	53.11
Tupaia (1)	1.6	0.9	56.25	56.25
Lemur Mongos (1)	3.9	3.0	7.69	76.90

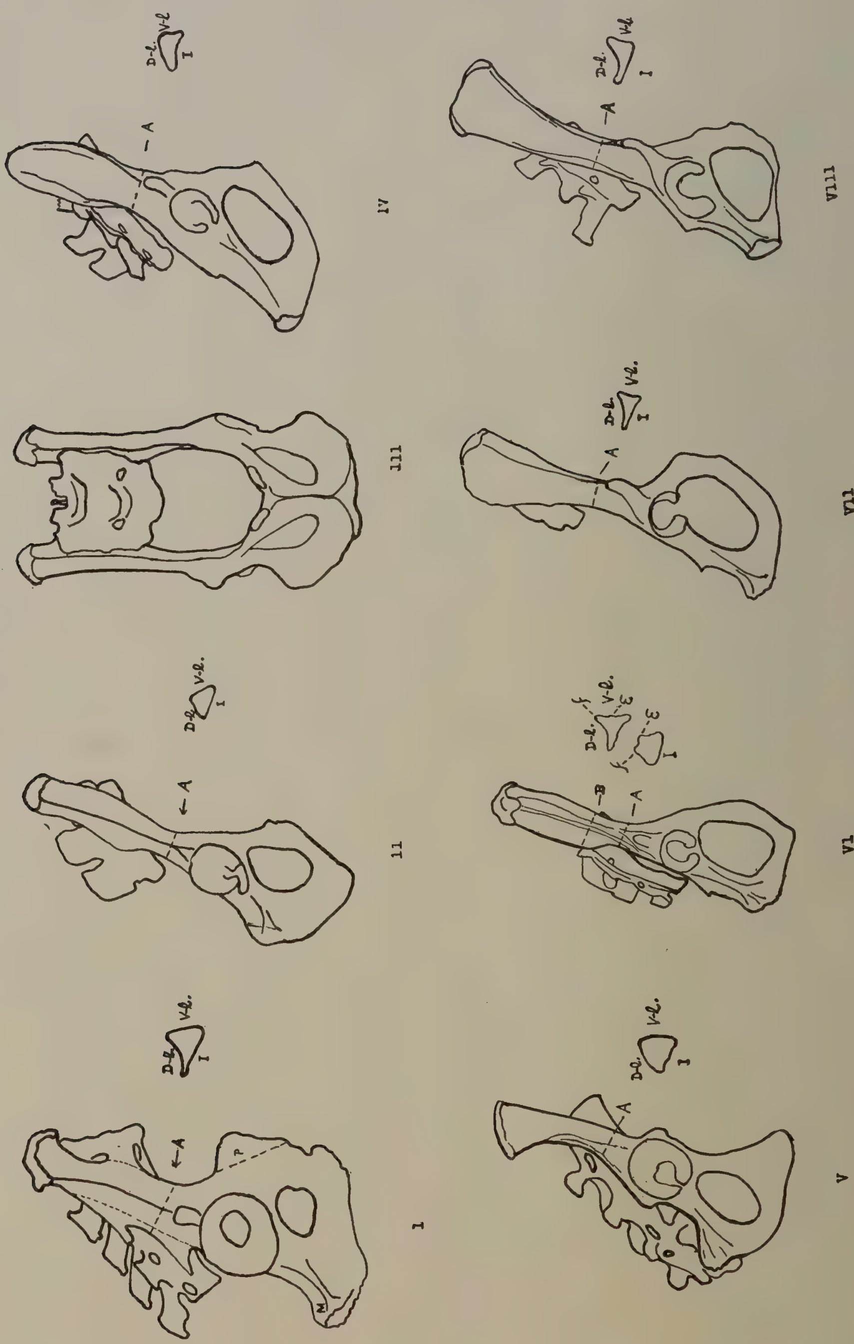


FIGURE 1

FIGURE 1

These pelves have been reduced or enlarged to an approximately uniform size to facilitate comparison. In all, the dotted lines *A* or *B* indicate the position at which the adjoining cross section of the ilium was taken. *I* is opposite the internal surface, *D-l,* the dorso-lateral, *V-l,* the ventro-lateral.

All have, in general, the primitive characters enumerated in the text, but all show some specializations, as noted below.

I. PROECHIDNA has a very large pectineal process (*P*), which is present, in varying shapes, in all the Monotremata; a metischial process (*M*), and a prominent pubis. The quadrupedal plate extends into the shank and alters the otherwise equilateral triangularity of the cross section.

II and III. DIDELPHIS has a slight metischial curve and some free ilium. It is as a whole very primitive. Note its very primitive cross section.

IV. GENETA is one of the least specialized representatives of a very highly specialized order.

V. MANIS has an edentate pubis, and a long metischial process.

VI. MARMOTA. The single line between the anterior spines represents the vestigial, primitive, external edge; the double line, the false anthropoidal plate. In the cross sections *A* and *B, e* is the vestigial external edge, *f,* the false plate. The true edge is less vestigial than in most rodential pelves. The free ilia are strongly bent, laterally outwards.

VII. TUPAIA. The resemblances in general shape and cross section between this and the lemur are interesting.

VIII. LEMUR MONGOS. The unusually ventral situation of the anthropoidal plate is a primate character.

[Figure 1]

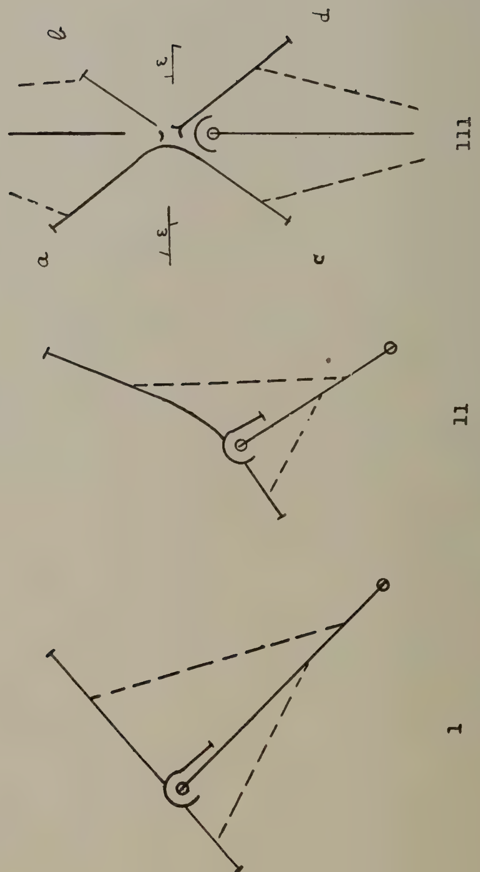


FIGURE 2

FIGURE 2

In these figures the heavy lines which are blocked at the ends represent the three pelvic arms, those with circled ends the femur, and the dotted lines the action of the extensor and flexor muscles. It must be understood that these dotted lines make no pretense of representing an accurate determination of the resultants of these muscles, which, indeed, it would probably be impossible to obtain.

The figures are, in fact, merely diagrammatic presentations of the conditions which may convey their meaning more clearly and easily than any verbal description. The iliac axes are each placed in an approximation to their usual position in a standing attitude.

I. THE QUADRUPEDAL. The proportions are taken from a fox (*Vulpes fulva*), an animal which is highly specialized for quadrupedal speed and endurance. It can readily be seen that with any great extension of the femur the muscles would lose power very rapidly.

II. THE ANTHROPOIDAL. The proportions are taken from a chimpanzee. It will be observed that the bend in the iliac axis throws the ischial axis so well backward that the muscles act to advantage, even though the femur is much more extended in relation to the ilium (and spine).

III. MAN. *a,* the region of the posterior superior spine; *b,* the tuberosity of the ilium; *c,* the tuberosity of the ischium; *d,* the pubis.

The dorsal curvature of the iliac axis brings it, essentially throughout its length, into line with the much elongated and strengthened pubic arm. It also throws the ischiatic axis into line with the newly developed tubero-acetabular line of strength. The muscles act to full advantage with both the femur and the trunk fully extended and erect. The same may be said of the lateral leverages, which, to avoid complexity, are not figured.

The leverages are, in fact, mechanically equivalent to those which would be exerted by a prolongation of the muscular resultants to a single plane (*E, E*), at right angles to the femur and trunk.

[Figure 2]

These are primitive proportions which persist in probably a majority of the whole class, but which are in marked contrast to the human specializations.[1]

Another very important characteristic of the general shape of all unspecialized mammalian pelves is that the ilio-ischiatic axis is nearly straight.

In detail: in all unspecialized mammalian pelves the ilium is an approximately straight, long bone, extending from the acetabulum to a sacro-iliac joint at, or nearly at, its distal extremity, i.e. with but little free ilium. In all of them, the body of the ischium from the acetabulum to the tuberosity is also a long bone, the axis of which continues the line of the iliac axis either exactly, or, as in most cases, at a slight dorsally-open angle.

The straight ilio-ischiatic axis and the femur form an inclined T in all quadrupeds of generalized structure (Figure 2), a fact which will become of much importance as the argument progresses, since it furnishes a key to an understanding of some of the most important modifications of the human pelvis.

In all mammalian pelves, the acetabular ramus of the pubes leaves the acetabulum at somewhat more than a right angle with the iliac axis, and extends thence to its junction with its fellow in the median line. This pubic acetabular arm is, moreover, with few exceptions, supported and converted into a bracket, as it were, by the conjunction of the descending ramus with the ascending ramus of the ischium.

A conception of the primitive pelvis as consisting, from a mechanical standpoint and when viewed from the norma lateralis, of an acetabulum, from which three essentially straight arms of bone project as levers, seems to the writer an important starting point for the study of pelvic evolution, and it will be so used in this paper.

TRIANGULARITY OF CROSS SECTION

The cross sections of the ilium are triangular throughout its length in all mammalian pelves of primitive type.[2] See Figures 1 and 2. In most of them this is equally true of the ischium from

1 Note that they are present in Lemur Mongos, representing the primitive Primates, as in all the other representatives of the primitive.

2 See also, Weidenreich, 1913, *Anat. Anz.*, p. 497.

the acetabulum to the tuberosity. In the Primates, in many Rodentia, in some Insectivora, and in occasional families throughout the class, the same is true of the pubic arm.

This triangularity of the cross sections is, moreover, detectable, at least in the acetabular ends of the ilium and ischium, in every mammalian pelvis.[1]

In all the more primitive pelves, such as are illustrated in Figure 1, the ilia and ischia plainly present for description three surfaces, the internal, the dorso-lateral, and the ventro-lateral; and three edges, the external, the dorsal and the ventral. These primitive edges and surfaces are, moreover, present in some degree, in every mammalian pelvis (Figure 3), and the process of tracing them out into the specializations furnishes an important key to the evolution of all their pelvic characters.[2]

In the most highly specialized pelves, as, for instance, in those of the Carnivora, of the Artiodactyla, and of man, the existence of these three edges is not always at once apparent. The writer has so far, however, found no single character which could not be traced back to the primitive, through intermediary stages, by the use of the conception that all individual specializations of the pelvis have been produced by alterations in the proportions of the triangular cross sections, or by the extension of plates or isolated processes from one or the other of these three primitive edges, often, however, in combination with alterations in the relative size, directions, and proportions of the three acetabular arms. This becomes very apparent as the bones are studied in quantity, but can only be shown here by quoting illustrative instances.

It must be remembered that an increased projection of any one of the three primitive edges involves, of necessity, an increase in the extent, and usually an alteration of the shape, of both the adjacent surfaces.

In order to avail ourselves of the full value of this concept, we must, moreover, go one step further in our study of the primitive.

In the pelves of the Prototheria, in those of the Metatheria of

1 So far, at least, as the writer's observation of the large osteological collection of the Harvard Museum of Comparative Zoology warrants the statement.

2 See also Strauss, 1929, *Studies on Primate Ilia.* This article also contains a very full bibliography of the pelvis.

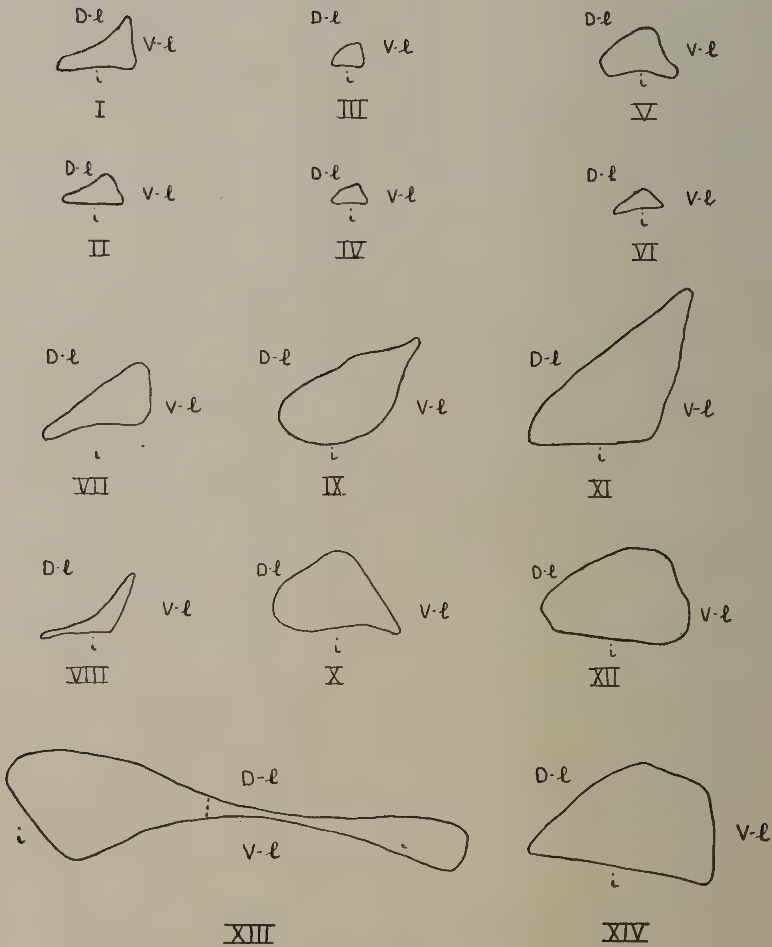


FIGURE 3

FIGURE 3

Throughout this figure the odd numbers represent lead strip tracings of the ilia, the even, those of the ischia, both taken as near to the acetabula as possible.[1] *i,* internal surface; *D-l,* dorso-lateral; *V-l,* ventro-lateral.

I and II. Zaglossus (*the spiny anteater*). The Prototheria, though the most primitive of mammals, are all highly specialized for swimming or digging, hence their pelves all show developments of extensive processes from the dorsal edges of their ilia and ischia.

III and IV. Didelphis (*opossum*) is a slow moving marsupial with a very primitive pelvis.

V and VI. Taxidea (*badger*) is a carnivore with a but slightly specialized pelvis.

VII and VIII. Antilocapra (*prong horn antelope*). It is an ungulate characteristic that in them the spine of the ischium is represented by a long thin plate which extends over the entire length of both the ischial and iliac shanks, which is here seen extending dorsally.

IX and X. Chimpanzee. In the chimp and in the very similar gorilla (XI and XII) the essential triangularity of both shanks is plainly apparent in spite of the high degree of specialization of their pelves.

XIII and XIV. Man. Both the shanks bear a general resemblance to those of the gorilla and chimp, but the section of the human ilium is here taken across the blade instead of from the shank, in order to show that even in that most highly specialized portion of a specialized pelvis the triangularity is clearly apparent if it is realized that the blade (the anthropoidal plate) is merely a process developed from the lateral edge. It must be noted that for economy of space this iliac section has been rotated from the others and should be viewed from the side, i.e. with the internal face (*i*) horizontal.

[1] Except in the human ilium.

[Figure 3]

generalized habits and structures, and in some of the most generalized of the Eutheria, the cross sections of the ilia and ischia are not only triangular, but are, at least approximately, equilaterally triangular.[1]

TABLE 3. WIDTHS OF SURFACES OF THE ILIAC SHANKS IN PRIMITIVE PELVES [2]

	Ventro-lateral	*Dorso-lateral*	*Internal*
Zaglossus (2)	1.2	1.3	1.8
	1.1	1.1	1.3
Didelphis (3)	0.6	0.6	0.7
	0.5	0.5	0.7
	0.6	0.6	0.8
Macropus (2)	2.4	2.4	2.3
	2.8	3.0	2.9
Marmota (4)	0.8	0.8	0.8
	0.8	0.8	0.8
	0.8	0.9	0.8
	0.8	0.9	0.8
Lemur (1)	0.8	0.11	0.8

If we assume provisionally that this equilateral triangularity is the primitive condition, we shall find that specialization by extension of any one of the three primitive edges has an individual significance of its own, both functionally and in systematic zoology, at least among the Mammalia.

1 This is true also in not a few highly specialized groups, though it is there limited, as a rule, to the acetabular ends only.

2 Here again many more specimens have been studied.

DEVELOPMENT OF SPECIALIZATIONS

THE writer not only believes that all pelvic specializations can be interpreted in this way, but also that this method of tracing out and classifying them, by following the successive stages of their development from one or the other of the three primitive edges, is not merely simple and practically successful, but that it is also a natural and fundamentally correct method. This is because it is evidently in accord with mechanical law.

If the problem of fitting to a shaft a socket which is to receive stresses in three directions is treated as an engineering question, it will be found that the lightest and most efficient method is to sustain the edges of the socket by buttresses, and to stiffen the shaft against the lateral stresses by extending the buttresses along it. This, in itself, creates triangularity of cross section and is just what nature does in the primitive ilium,[1] e.g. Didelphis (Figure 1).

Again, if a power-producing structure is to be installed at some point along the shaft, it would be natural to install it on a strut derived from one of the edges, in order to increase its leverage, precisely as is done in bone by nature, and, in each instance, on the edge which is best situated to direct the power-producing element, e.g. the attachment of the erector spinae muscles to the long spinous processes of the vertebrae, perhaps best seen in the ungulates, in whom powerful extension of the spine is essential to the speed on which their lives depend.

This, then, seems to afford a reason for the success of this method of study. This subject is, however, a large one, and no extended discussion of variations in other directions than towards the use of the erect posture is in any sense germane to the purpose of this paper. A few instances of similar pelvic specializations may, however, be mentioned here, as illustrations of the general subject.

It is, for instance, noticeable that the development of speed and activity in quadrupedal locomotion tends typically to the acquisition of ilia which are extended dorso-ventrally into flattened blades by plates developed from the primitive dorsal, or dorsal and ventral edges. These, in the most typical instances

[1] In the case of the heavier and more specialized animals, the shape is somewhat modified by the more advanced internal architecture of the bone.

indeed, occupy very nearly parallel dorso-ventral planes, as in the lion (*Felis leo*), in Figure 4, VII. In fact, in many quadrupedal groups, as, for instance, among others, in the heavier Carnivora, and in the edentate armadillos (*Dasypodidae*), even the shank of the ilium also has become a flattened beam, with its breadth extending dorso-ventrally.[1] This is evidently an adaptation to the direction of the thrust received from the femur in the quadrupedal attitude.

As an illustration of another specialization see the mule deer (*Odocoileus hermionus*), Figure 4, VI, which shows a strongly marked example of a plate to be referred to hereafter as the quadrupedal plate. This is developed to a greater or less degree in most quadrupeds from the primitive dorsal edge at the level of the sacro-iliac articulation. The value of this plate is evidently that it furnishes to the quadrupeds an opportunity for a dorso-ventrally directed extension of the weight bearing ilio-sacral articulation. It is largest in those of great weight or activity and as it is quadrupedal, it disappears or is decreased in the Simiidae and man.

The development of a metischial (or dorsally directed) process from the primitive dorsal edge of the ischium, as in Manis (Figure 1), or very prominently in Ornithorhynchus (unfigured), is another instance. This gives power to the hamstring muscles in the extension of the femur. It is common in diggers, swimmers, and jumpers.

Many other instances of specializations derived from the primitive ventral and dorsal edges might be quoted, but they have no direct bearing upon the development of the erect posture, which is especially associated with extensions of the external primitive edge of the ilium, in combination with changes in the shape and proportions of the sacrum and of the pubic and ischiatic acetabular arms. The writer hopes that the truth and force of this statement will become apparent as the argument develops.

[1] The methods by which this shape is produced are, however, different in the different orders. In the armadillos it is produced by an extension from the ventral, but in the Carnivora, from the dorsal edge. In the latter, it is, in its varying degrees, a strong ordinal characteristic.

THE ANTHROPOIDAL PLATE

In every case that has been observed, the adoption of any considerable use of the erect attitude by an animal of any sort is attended by the appearance of a plate developed from the primitive external edge of the ilium and, consequently, extended laterally. The degree to which this plate, which for convenience will be referred to hereafter as the anthropoidal plate, is developed is, moreover, always correlated with the degree to which an erect attitude of the trunk has been perfected and adopted by the given group (family, genus, or species).

Even animals which have only an erect sitting habit show some extra development of the primitive external edge, while in the few animals in which the use of an erect attitude has become a frequent and important life habit, the extension of the primitive external edge, and consequently of the dorso-lateral and ventro-lateral surfaces, results in the formation of much extended iliac blades which project laterally or transversely in very nearly the same plane with each other (Figures 4, VIII; and 6). It will be seen later that the development of this plate gives greatly improved leverages to the muscles which erect the body, and also affords to many of them an opportunity for increased power by enlarging their sites of origin.

The anthropoidal plate can be traced and recognized, even in its most specialized forms, by the fact that the external primitive edge from which it is developed always begins in the anterior inferior spine (present in all mammalian pelves), and extends continuously to its end at the crest, where the anterior superior spine is usually recognizable as its termination.

The development of the anthropoidal plate in the ilium is, then, the most prominent and striking of the localized specializations which we shall come to recognize as characteristics of the erect posture in any form. The changes in the sacrum, ischium, and pubes, which are to be described later, are chiefly related to the appearance of an erect, alternate, bipedal progression, and govern the increased extension of the femur, which in one degree or another is essential to all such erect locomotion.

BALANCE AND BASE OF SUPPORT

The discussion of these specializations, the study of their mechanical significance, and of its influence on their development, is our immediate subject. Their necessity to the erect position can hardly be made fully comprehensible, however, without some preliminary consideration of the principles of balance as applied to the animal body in that position. In this connection we must also recognize not only the pelvis and the pelvic muscles, which are the chief agents in effecting and maintaining the erect balance, but also the equally important base of support on which the whole structure rests. In the erect sitting position this consists of the buttocks and feet, in the erect standing position, of the feet only.

No digitigrade animal makes any essential or habitual use of an erect bipedal position. The extent of base afforded by plantar feet is essential to this posture.[1]

In general, the degree of stability of any erect object is determined by the proportion between the diameters of its base of support and the height of its center of gravity.[2]

The animate body has, however, two advantages which give it far more chance of maintaining an erect standing position than those of an inanimate object with the same height of center and diameter of the base of support. The first of these is that it can, by movements of its trunk, adjust its center of gravity to the position of its base in any variations of its attitude, and the second, that it can at any moment extend that base in any desired direction by shifting the position of a foot.

Since both of these two adjustments are, however, executed by muscles which originate from the pelvis, the degree of activity and power in executing such movements which any given animal possesses is plainly dependent upon the mechanical advantages which are afforded to its muscles by the shape and proportions of its pelvis.

1 Certain digitigrades, however, make frequent use of an erect sitting or standing position upon a tripodal base composed either of the two hind feet and haunches, or of the hind feet and a powerful tail. Since both of these postures involve some degree of pelvic specialization, they are of considerable interest, and must be studied as showing transitional stages towards the more complete specializations.

2 In all studies of balance the whole weight of the object should, of course, be considered as concentrated at the center of gravity and, equally of course, a perpendicular dropped from that center must remain within the area of the base, or the object falls.

As has been said, the most striking and the most important of the pelvic modifications which are related to the erect posture is the development of the anthropoidal plate, since it is present in all degrees of the assumption of this habit.

In maintaining the balance of the erect trunk upon the pelvis, and consequently upon the base, the antero-posterior (i.e. dorso-ventral) and the lateral motions are plainly of equal importance.

Since in the erect postures of all animals (from the erect sitting animals to man) the center of gravity of the trunk is always anterior (i.e. ventral) to the acetabulum, the maintenance of antero-posterior balance is mainly governed by the erector spinae group of muscles. This group is not greatly affected by the development of the anthropoidal plate, but it is so important and powerful an element in quadrupedal progression that it is probably always sufficient for its part in the erection of the body, if that is needed. In man and the anthropoids it is, however, considerably widened and, therefore, increased in size by an extension of its lateral elements along the inner lip of the iliac crest.[1] The increased size of the glutei which follows the development of the anthropoidal plate is also an aid to the erection of the trunk in even the sitting animal, since even in them these muscles contribute to the fixation of the pelvis from which the action of the spinal muscles originate.

The existence of the anthropoidal plate is all-important to the equally important matter of lateral balance of the body. The muscles which govern lateral flexion and extension all take origin from the iliac crest, and both their size and their mechanical advantage in leverage are greatly increased by the lateral extension of that crest which is due to the presence, in all of them, of the anthropoidal plate.

As we review the mammals it will be found, as has already been said, that the development of the anthropoidal plate proceeds *pari passu* with the degree of adoption of an erect habit.

[1] Keith, 1923, *Posture of Man*, p. 451.

SPECIALIZATIONS OF THE ISCHIA AND PUBES

FREQUENT use of even a bipedal standing position by any animal may sometimes involve some additional pelvic specializations, which increase in prominence and complexity with the adoption of bipedal progression. These occur in the ischia and pubes. They are chiefly related to a changed position of the femur which favors the erect posture. Most such animals, however, still retain a quadrupedal gait, and the degree to which the bipedal habit modifies the pelvis is, of course, dependent upon the frequency and importance of the use of this posture to the individual animal, as compared with his habitual quadrupedal gait.

Comprehension of the relation between these pelvic specializations and extension of the femur is essential to an understanding of the erect bipedal gait, and its lesser degrees must be discussed here.

In animals adapted to the quadrupedal attitude only, the median position of the femur, its position when it is in least active use, i.e. when the animal is standing at ease, is not far from a right angle with the ilio-ischiatic axis, or perhaps usually slightly more flexed. In this position the attachment of the muscles to the straight ilio-ischiatic axis furnishes them with admirable leverages for action upon the femur so long as its motion is restricted to an arc of moderate extent upon either side of this position (Figure 2, I). A little consideration of the figure will show, however, that in a position of extension of the femur the pelvic leverages would be so decreased that none of the muscles arising from the straight ilio-ischiatic axis would be in a position to exert any effective traction upon it.

The femur of quadrupeds of generalized habits and structure is rarely carried into really great, and never into extreme extension; indeed, in most quadrupeds its arc of motion is probably much less wide than we are apt to think, most of the extension of the limb as a whole being in reality obtained from its lower articulations.

In certain quadrupeds of specialized habits we do, however, see some slight approach to specialization towards the use of the femur in extension. This occurs in fossorial animals and in those which are great leapers. Diggers usually excavate the dirt with their fore paws and kick it far behind them with their hind limbs, and all leapers must make a powerful effort with their hind limbs after their body is directed upwards; both are naturally aided by somewhat greater extensions of the femora than are necessary in their ordinary terrestrial progression. These animals always show some metischial development and some increased ventral projection of the pubis. Consult the shapes of the ischia and pubes in Proechidna (Figure 1), in Odocoileus (Figure 4), and in Leo (Figure 4). These metischial and pubic changes are interesting as instances of a slight specialization towards a more than quadrupedal extension of the femur, which occurs in perhaps a more decided form in certain bears (*Ursidae*), and which may be regarded as an intermediate stage between the quadrupedal form and the developments of the lower pelvis which are peculiar to the Simiidae and man.

STAGES OF DEVELOPMENT OF THE ERECT POSTURE

THE several stages in the development of the erect posture which appear in the mammalian series may be defined as an erect sitting posture from a tripodal base consisting of the hind feet and the buttocks; a standing posture upon a tripodal base composed of the hind feet and tail; [1] an erect standing position upon plantar feet without bipedal progression; erect, alternate, bipedal forward locomotion, such as occurs, for example, in the anthropoid apes and in some bears; and the more complete bipedal activity which belongs to man alone (see p. 310). Each of these degrees of erectness has its characteristic degree of pelvic specialization.

Instances of partial use of the erect habit occur, as has been said, in some species among the Marsupiala, the Edentata, the Carnivora, the Rodentia, and in many Primates. Each of these instances must now be discussed in some detail in support of the theories which have been outlined, and as transitional stages towards the fuller specialization which exists in man.

THE KANGAROO

The pelves of the subclass Metatheria as a whole are primitive, but are interesting from the very diverse specializations which occur among them. The group has, of course, developed independently, and in its Australian habitat contains animals of quite varied habits. The pelves of its members often parallel those of the Eutheria of similar habit to a very curious degree, for instance, that of Sarcophilus, a highly predatory animal, has ilia which, though developed by a different method, closely imitate in shape and appearance the main characteristics of those of the Carnivora.

The Macropodidae (the Kangaroos and Wallabies), the only members of the group which make any use of even a partially erect attitude, are closely alike, and, for our purpose, may be described as one. When grazing, or in slow motion, they have an awkward but strictly quadrupedal gait. When in rapid motion

[1] Neither of these bases permit any progression.

they are bipedal, and appear to be wholly, or almost wholly digitigrade. They then progress by a series of hops or leaps, in which the hind limbs are used simultaneously. In this gait they evidently maintain their balance, in spite of their digitigrade base of support, by availing themselves of the inertia of motion and by an adaptation of the successive positions of their feet to its guidance.[1]

The effect of the inertia of motion in holding the progress of such a body to a straight line is, moreover, just as valuable in preventing vertical variation downward or upward. This is a very important mechanical principle which should not be forgotten in considering the gaits of the various animals which are to be studied.

When at rest, and especially when on the lookout for enemies, they bring both their long tarsi and their powerful tails to the ground, and thus obtain a very extensive base of support by a combination of the plantar and tripodal methods. In this position the body is erect, and the burden of its weight is well distributed between the feet and tail.

The pelvis (Figure 4) is but moderately modified from the primitive. The ilio-ischiatic axis is straight and thoroughly quadrupedal when viewed from the norma lateralis; but the free ilia extend a long way above the synchondrosis and are widely bent, laterally outward. The anthropoidal plate is developed in the smaller species to about the prominence and shape which is functionally present in those of the rodents which have a well developed sitting habit (*Marmota marmota,* Figure 1, VI), and in the very heavy Macropus giganteus to a somewhat greater degree.

The ischia have a moderate metischial (i.e. dorsal) extension, and the pubes are ventrally prominent. The symphysis is long.

It would seem at first sight that this pelvis showed an insufficient degree of pelvic development to correspond to such habits in so heavy an animal as the giant kangaroo, and that a doubt

1 Any body in motion has a tendency to follow a straight line unless its path is disturbed by some other force. This inertia of motion increases with the weight of the moving body and with the rapidity of its motion. With a heavy animal in rapid motion it becomes an important factor, making the maintenance of balance much easier and considerably lessening the effort required from the muscles in maintaining straightforward progression. This is very noticeable in the human use of the bicycle. Compare its instability when moving slowly with its security of balance when at high speed.

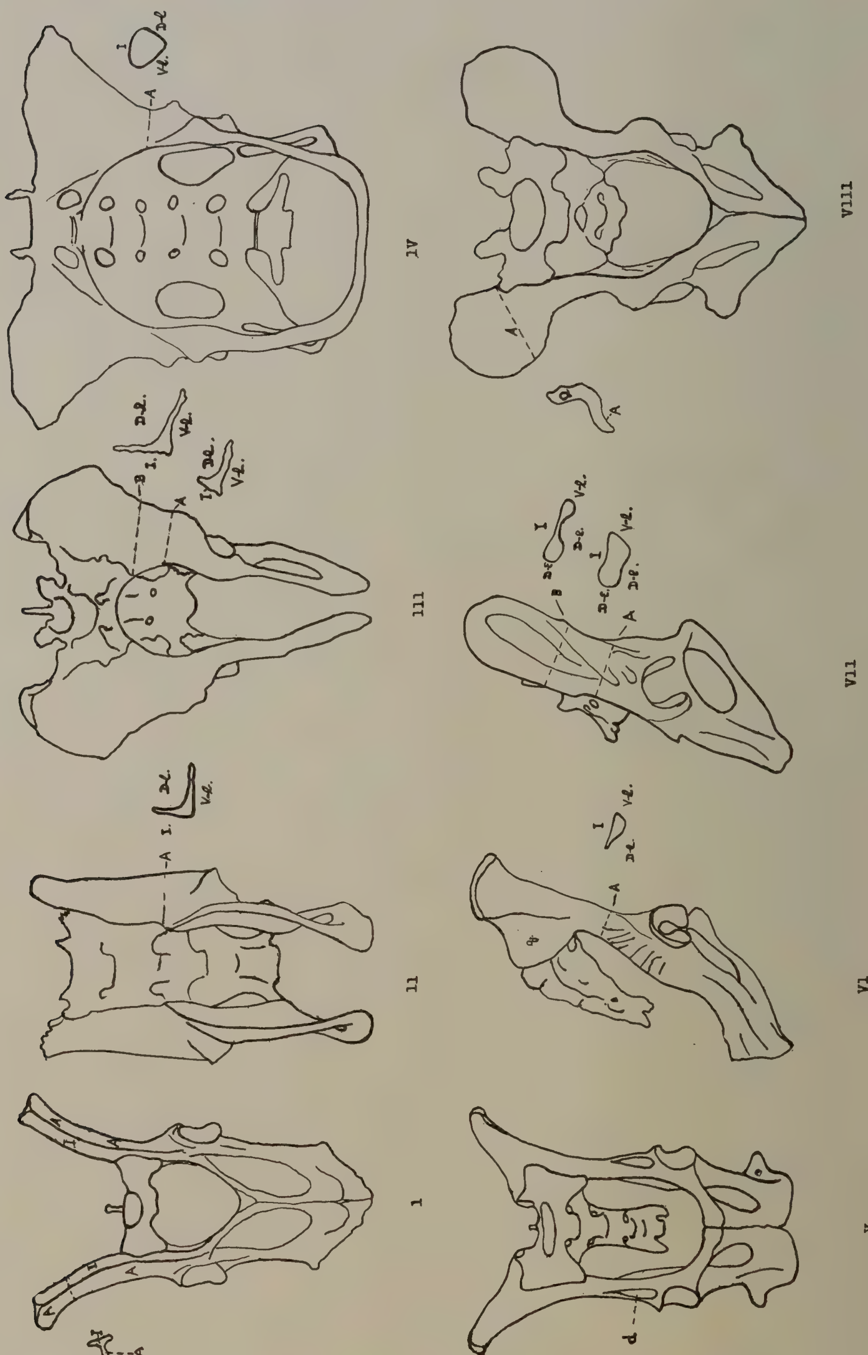


FIGURE 4

FIGURE 4

These pelves have been reduced or enlarged to an approximately uniform size to facilitate comparison. In all, the dotted lines *A* or *B* indicate the position at which the adjoining cross section of the ilium was taken. *I* is opposite the internal surface, *D-l,* the dorso-lateral, *V-l,* the ventro-lateral.

I. The giant kangaroo (*Macropus giganteus*). The leaping characters are strongly developed but are best seen in a lateral view. It is shown here in illustration of the first degree of development of the anthropoidal plate, *A,* and of the lateral bend of the long free ilia.

II. Cyclotura didactylus.

III. The great anteater (*Myrmecophaga jubata*).

Both these animals have developed extensive anthropoidal plates in response to their frequent and vitally necessary habit of lateral and antero-posterior swaying movements of the trunk in an erect posture, but their retention of the weak edentate pubis shows beautifully the unimportance of the pubic arm to the maintenance of an erect position, so long as bipedal locomotion is not attempted.

IV. *Bradypus tridactylus.* See Appendix.

V. and VI. The mule deer (*Odocoileus hermionus*). Another highly specialized quadruped with a quadrupedal cross section of the shank, but with some degree of the widely spread iliac blades which are an ungulate characteristic (see Appendix). Note the large quadrupedal plate, *q*. Note also the long, metischially directed ischiatic axis and the strong pubis, which respectively aid in the extension and recovery of the femur in the leap.

VII. Felis leo. The pelvis of a highly specialized quadruped. Note the long straight ilio-ischiatic axis, the dorso-ventrally directed cross section and the similar direction of the blades. Note also the added characters of the leapers, the very long ischium (not in this instance metischially curved), and the ventrally projecting pubis.

VIII. Ursus (*species unidentified*). The small but fairly well developed and laterally widely spread anthropoid plates, the large metischial and parischial processes, and the very strong and prominent pubes are somewhat imperfect adaptations to erect, bipedal progression, especially in so heavy an animal. They are, however, evidently sufficient for its very moderate degree of this habit.

It is noteworthy that the bears are unique among quadrupeds in combining these three pelvic characters with plantar feet, and that they, alone, make even an occasional natural and untaught use of an alternate, bipedal, walking gait.

The cross section shows the combination of a quadrupedal (*Q*) and an anthropoidal (*A*) plate which is again appropriate to their habits.

[Figure 4]

of the importance of the anthropoidal plate in particular was thereby created. This apparent discrepancy is, however, explained by the peculiar balance of the kangaroo, which is easily observed in any zoological garden. Both when in bipedal motion, and during the very brief moments when it is at rest in a bipedal position, the balance of the kangaroo's trunk upon its hind legs is very like that of most birds. The short femur is held very rigidly in a flexed position at the sides of the abdomen; the heavy tail is extended as an important counterweight; the center of gravity is nearly above the knee joint, and balance is chiefly maintained by the muscles which control the knee. The kangaroo is, in fact, a much less erect animal than is commonly supposed, an occasional use of the erect sitting position from a tripodal base being really the only degree of erectness to which it attains, and even when the tail is in contact with the ground and the base is tripodal, the same quadrupedal position of the femur is maintained.

When in the erect sitting position, the animal is, however, capable of making considerable swaying motions of the body without carrying its center of gravity outside its wide tripodal base of support. In these motions the pelvio-corporeal group of muscles is subjected to an increased functional demand and an evolution of improved leverages for their action does become advantageous. The erector spinae group is already powerful and is continued without interruption into the heavy tail. No change is needed to permit the extension of the spine, but since the muscles which govern the lateral flexions arise largely from the iliac crest, the advantage of more lateral situations for their origins is at once apparent. This is given to them by the wide lateral curve in the free ilia, and is probably very necessary to the lateral swaying motions.

On analysis the ilia then prove to be modified to about the degree which would be expected from the animal's habits.

The changes in the ischia and pubes about correspond to those which are present in the pelves of the other leaping quadrupeds and are evidently correlated with the animal's bipedal hopping habit when at speed.

It will be noted later that in the lower Primates also, a hopping or leaping gait, in which the hind legs are used simultaneously, requires extremely little modification of the pelvis, the reason being, undoubtedly, that given above; that it requires but little effort from the muscles of the trunk, the balance being maintained mainly by management of the inertia of motion.

THE ANTEATER

In the order Edentata the sacrum, ischia, and pubes are considerably specialized in a manner which is distinctive of the Edentata, and of them only.[1] The ilia are, on the other hand, very primitive except among the anteaters[2] (*Myrmecophagidae*). They, the only members of the order which make any use of an erect attitude, have, in accordance with their habits, developed fairly wide iliac blades from the external primitive edge.

The small anteaters, of which the smallest, Cyclura didactylus (Figure 4, II), may serve as a good example, are arboreal. Their tails are long, with powerful flexor muscles, the action of which is increased by the existence of chevron bones opposite the bodies of the vertebrae. Cyclura has peculiar, but very efficient, grasping feet, especially well developed on the hind limbs. It lives among the small branches near the tops of high trees. It has a habit of grasping a branch with its hind feet, another with its prehensile tail, and upon the extensive tripodal base so obtained not only erects its body, but bows and sways to and fro, apparently for amusement. It probably often pursues the ants upon which it feeds by the same motion.[3] It is of about the size of a very large rat, and is very lightly built, but with this erect feeding habit it has developed an anthropoidal plate which is more complete than that of any animal outside its own family, except those of the anthropoid apes (*Simiidae*). The remainder of its pelvis is, like those of all the other anteaters, unmodified from the peculiar edentate type; the reason being, of course, that the position of its thighs is quadrupedal, even when it is in the erect posture, and that its locomotion is always quadrupedal.

The great anteater, or ant-bear (*Myrmecophaga jubata*), is a large and heavy terrestrial animal (Figure 5). Its locomotion is

1 The ischia and sacrum are long and firmly united, while the pubis is usually absent or ligamentous.

2 See Appendix, however, for the pelves of Bradypus and the extinct ground sloths.

3 Cyclura is a very delicate animal which does not survive removal from the tropics, but is easily kept alive in captivity for short periods there.

wholly quadrupedal. Its hind legs are long, its fore legs short. It walks upon the outer surface of the long claws of its front feet, but has a well developed plantar tread with the hind legs. It feeds mainly, if not wholly, upon termites, whose elevated nests it tears open with the powerful claws of its fore feet. These

FIGURE 5

MYRMECOPHAGA JUBATA. At the moment of this picture the tail with its heavy load of hair was not in use as a counter weight.

claws are also its only weapons of defense. When feeding or defending itself it often adopts a very thoroughly bipedal attitude upon its plantar hind feet. Its long and heavy tail is not applied to the ground, but is usually elevated and extended as a counterweight. In this attitude it rips open the termite nests, pursues the escaping termites with its tongue, and is said to be capable of very powerful sweeping blows with its fore claws when attacked by an enemy. Myrmecophaga is a frequent inhabitant of the zoos, and although it is not fed on ants there, it not infrequently adopts the erect attitude, when its easy and extensive swaying movements from its bipedal base are readily observed. It drops to a quadrupedal gait if it wishes to shift its position even a few inches. Even in the erect attitude its femora are in the quadrupedal position, hence no modification of the lower pelvis is necessary, but it has an anthropoidal plate which is quite equal to that of the gibbon, and is exceeded in development only by those of the three heavier anthropoid apes (Figure 4, III). The other portions of its pelvic girdle are closely like those of the other and wholly quadrupedal edentates. The defective pubes and poorly developed ischia of its order deprive it of any power of bipedal progression.

THE RODENTIAL SITTING HABIT

The Rodentia are of special interest in arguing the importance of the anthropoidal plate to the erect posture on account of a modification of the ilium which is peculiar to this order. The most striking and fixed ordinal characteristic of the rodential pelvis is that in it the primitive external edge has become vestigial. In some Dipodinae it is apparent as a slight ridge, in Thryonomys swinderianus there is a transitional form, but in all other rodential pelves it is represented merely by a vestigial marking.[1]

The necessary mechanical function of stiffening the iliac blade against transverse strains, which is in almost all other pelves supplied by the persistence of the external primitive edge in greater or less degree, is in most rodential ilia furnished by a thickened band in the dorso-lateral surface, which is peculiar to this order. It starts in the primitive dorso-lateral surface, nearly opposite the anterior inferior spine and terminates in the crest (Figure 1, VI). In the blade this new band lies dorsal to and nearly parallel with the vestigial evidences of the primitive external edge on the surface of the blade, and in those rodents which use an erect sitting attitude this band becomes a prominent ridge

1 So far, at least, as the writer's study of the somewhat large rodential collection of the Harvard Museum of Comparative Zoology warrants the statement.

(*Marmota marmota,* Figure 1, VI), and thus effects a transverse extension of the blade which might easily be mistaken for a true anthropoidal plate if it were not for the vestigial marking alongside it. This development occurs in some squirrels (*Sciurinae*), in many marmots (*Marmotinae*), and in the beavers (*Castoridae*).

The stiffly erect sitting position, which many marmots use when alarmed, which some squirrels at times use when feeding, and which beavers sometimes adopt when felling trees,[1] must be carefully distinguished from a squatting position with relaxed back which is common to many small animals. In both, the hind legs are flexed and the buttocks and feet form a tripodal base of support. In the common squatting position the knees are pressed against the abdomen, the spine is relaxed and curved forward, the weight of the body is sustained by the knees, and no essentially increased action of the pelvio-corporeal muscles is involved in its use. In the erect sitting position, on the other hand, the spine is held stiffly vertical, the abdomen is free of the knees, and the pelvio-corporeal muscles are in full action.

This latter attitude has all the appearances of a stage in the development of the erect posture. From analogy with the other partially erect animals we should expect that this habit would be accompanied by the development, to some degree, of an anthropoidal plate, with elongated and laterally extended free ilia, but with no other change in their pelves, since there is no possibility of the use of the limbs in bipedal progression from this attitude. In point of fact, these pelves show almost precisely the same shape of ilia that characterizes the smaller kangaroos, although it is obtained by an entirely different method of origin.

That this shape has been attained by a new development in some members of an order which, as a whole, has suppressed the primitive external edge, and that it only occurs in animals which are known to have the erect sitting habit, seems to be of especial interest.[2]

1 Statement justified by personal observation of a wild beaver.

2 The writer is conscious that the argument from the Rodentia would be rendered complete only by evidence that those Sciuridae which are without this false anthropoidal plate are not in the habit of using the true erect sitting position, but this negative proof would require an amount of varied field knowledge which he is unable to supply.

THE BEAR

A somewhat similar example of the development of the functional anthropoidal plate in a single family within an order appears also among the Carnivora. Most of the members of this order are wholly predatory, and their pelves are, as a rule, specialized towards efficient quadrupedal activity and speed of motion. The chief ordinal character is iliac. The primitive external edge typically merges with the ventral edge almost immediately after leaving its origin in the anterior inferior spine. The combined edge so formed is thick and strong, and the dorsal edge thickens to correspond; the blade between them is thin. Both shank and blade are thus formed almost wholly from the primitive dorso-lateral surface and the internal, the ventro-lateral being almost wholly effaced. The long diameter of all the cross sections runs approximately dorso-ventrally, and the blades throughout lie in nearly parallel dorso-ventral planes. In the most typical pelves the combined edge is very short, ending in the anterior superior spine shortly above the acetabulum, and a large part of the blade is thus formed by a cephalad extension of the crest, as in the lion (*Felis leo,* Figure 4, VII).

One single family of Carnivora is not wholly quadrupedal. The Ursidae have developed hind feet with plantar treads. Some of them,[1] at least, are capable of assuming a fairly well developed erect bipedal standing position, and even of using at times, and for short distances, an awkward, waddling, bipedal walk. Their pelves show a corresponding variation from the ordinal carnivoral type.

In them the shank still suggests the normal carnivoral shape, the dorsal edge is thickened, and the ventro-lateral surface much narrowed. This surface is, however, distinctly a surface, and the external edge persists as a distinct entity, even in the shank. As it passes into the blade, moreover, it separates from the ventral edge and expands laterally into a well developed anthropoidal plate (Figure 4, VIII). The anterior superior spine resumes its

1 The several genera and species are said to vary greatly in the frequency and extent to which they use the erect position. There is certainly a noticeable variation in the degree of pelvic specialization.

primitive position and the crest is well developed and shaped as in the other orders.

The ilium as a whole is thus to a very considerable degree specialized for the erect posture, as would seem inevitable if so heavy an animal is to use any degree of that attitude, yet its carnivoral method of development is still plainly recognizable.

The sacrum is wider than in typical Carnivora, its spinal processes are well developed, and the posterior superior spines of the ilium are prominent and wide apart. These conditions in combination with the well developed and laterally extended iliac crests, are all provisions for large and well situated origins of the pelvio-corporeal muscles.

The parischial [1] and metischial processes are prominent and strong, the pubis is ventrally prominent, and the pelvis as a whole is short, wide, and deep, as compared with most other Carnivora. These specializations of the lower pelvis are favorable to erect bipedal progression. As compared with the human specializations, they are very moderate, indeed slight, but it is noteworthy that we see them for the first time in the first, and perhaps the only quadruped in which true, erect, alternate, bipedal progression is a natural factor in habit.

THE PRIMATES

With the Primates we reach pelves which have a direct bearing upon the pelvis of man, since their owners are members of his own order.[2] All Primates, including man, therefore, attain their specializations, of whatever degree, by the same ordinal methods. It will then be necessary in this order to refer at least briefly to the pelves, not only of each family, but at times of lesser groups, as illustrative of the steps by which the human pelvis has probably evolved along its own and collateral stem.

The primate pelvis has a well marked ordinate character, which is not shared by any other order, in the persistence and prominence of the primitive external edge in all three of the pelvic arms, i.e. the ilia, ischia, and pubes.

Throughout the order there is a considerable development of

[1] A laterally extending process developed from the external primitive edge of the ischium, usually close to, or on the edge of the tuberosity.

[2] See Schultz, 1930. *The Skeleton of the Trunk and Limbs of Higher Primates.*

the free ilium. Throughout the order also there is a reduction of the primitive ventral edge, so that the strongly developed external edge is situated close to the ventral line of the ilium. The cross section therefore tends to an L shape (*Lemur mongos*, Figure 1, VIII). In all but the most generalized members of the order, the primitive external edge is developed into an anthropoidal plate, and this is prominent from its origin in the anterior inferior spine to the crest. The shank is usually rather long and merges gradually into the blade. In the ilia of the order as a whole, there is also a considerable development of the quadrupedal plate from the dorsal edge, but this is much reduced in the Simiidae and in man.

In the ischium the presence of a triangular cross section is fairly well marked throughout the length of the descending ramus in all the families, and there is always some indication of a parischial process, at least in the presence of a lateral projection in the edge of the tuberosity.

In the pubes triangularity of cross section from the acetabulum to the symphysis exists throughout this order. It is rare, and is limited to small groups in the other orders.

The primate pelvis is the more interesting from the fact that although the ordinate characters are preserved throughout, the several families exhibit every stage of habit and posture, from the quadrupedal to the erect bipedal, and exhibit equally clearly the corresponding degrees of specialization in the pelvis.

Lemuroidea. The lemurs are mostly arboreal. As seen in the zoos, their movements about the cage are quadrupedal, but varied by very active bipedal leaping. It is reported that in their native habitat, when seen upon the ground, they progress when pressed by rapidly repeated leaps or hops, but do not walk. They have and use constantly a very fully developed erect sitting posture.

The general shape and proportion of their pelves is primitive. The anthropoid plate is less well developed than in the true Primates, but it is primate in situation and exists as a definite, though narrow, plate from the anterior inferior spine to the crest (*Lemur mongos*, Figure 1, VIII). It is perhaps somewhat more definitely developed than that of any other animal which approaches the erect posture only by a sitting position. The symphysis pubis is strongly inclined, and the angle of the pubis projects strongly ventrally. This feature is always characteristic of leapers (*Felis leo,* Figure 4, VII, and *Odocoileus,* Figure 4, VI). Most great leapers also show a metischial development, which the lemurs do not. The descending ramus of the ischium is, however, rather unusually long, and this, to a certain extent, favors extension of the femur.

It is difficult for the eye to follow the rapid movements of such very active animals, but it is evident that during the greater part of the motion the thigh is within the limits of the quadrupedal position, and it is probable that it is never carried into great extension, even in the leap. They are otherwise strictly quadrupedal and they have quadrupedal pelves, but with the degree of anthropoidal plate which corresponds to their sitting habit.

Tarsius [1] and Daubentonia are nocturnal, arboreal quadrupeds with subequal limbs. Tarsius hops actively. Their pelves are primate, primitive, and lemuroid.[2] They are not of any special interest here.

Anthropoidea. This suborder includes five families, of which the Hapalidae and Cebidae are confined to the New World, and the Simiidae and Cercopithecidae to the Old World. The Hominidae is the fifth.

The marmosets (*Hapalidae*) are arboreal quadrupeds. They have long bodies and rather short subequal limbs, a generalized type of quadrupedal construction. All four paws are equipped with sharp claws, with which they cling to the bark of the trees as they move about. Their locomotion is thus strictly quadrupedal. They make a considerable use of a squatting posture, but in this attitude the trunk is allowed to curve forward in flexion, and its weight is apparently largely supported by the thighs and knees, which rest against the abdomen. The spine is not held extended, and the attitude cannot be described as an erect sitting posture.

Their pelves correspond with their development. They show the primate characters in sufficient degree to make them recognizable as primate pelves, but the general shape of the pelvis is primitive and consequently quadrupedal. The primitive external edge is

1 Colton, 1930, *Biped Habit.*

2 Hopping from both hind legs is leaping. It requires the ischial and pubic characters which belong to all leaping quadrupeds, but not those which belong to alternate bipedal progression and its balance.

preserved throughout the ilium, and in the ventral position characteristic of the Primates, but it is not elevated into an anthropoidal plate. The blade is formed almost wholly by the dorso-lateral and internal surfaces, and, consequently, the long diameter of the cross section extends dorso-ventrally. The ischia and pubes are primitive and unspecialized in their shape and character.

The New World monkeys [1] (*Cebidae*) may for our purposes be divided into two groups, those with prehensile tails (*Mycetinae* and *Cebinae*) and those whose tails are non-prehensile (*Pitheciinae* and *Nyctipithecinae*). The pelves of these two groups differ, and differ most conclusively, in accordance with a corresponding difference in their locomotive habits. All are completely arboreal, but the Pitheciinae and Nyctipithecinae, with non-prehensile tails, are small animals which apparently move about the branches with all four paws used as grasping organs, and, of course, without any other assistance in their locomotion.

Their pelves are but little specialized in any direction, and closely resemble those of the Hapalidae, with a little, but very little more development of the anthropoidal plate.

The prehensile tailed monkeys, Alouata, Ateles, Lagothrix, and Cebus, have, as a whole, pelves with large and well developed anthropoidal plates, but the degree of this development varies considerably both among the several genera and species, and often between individuals within them.

In Alouata, Ateles, and Lagothrix the anthropoidal plate is widest at the crest; the crest itself is thick and strongly developed. The sacrum is wide and has very strong and prominent spinous processes. All these characters are, of course, especially fitted to give advantages to the pelvio-corporeal group of muscles.

The ilio-ischiatic axis is quite straight; the free ilium is shorter than in other anthropoids; the ischium and pubes are rather primitive and unspecialized.

In action these animals frequently plant their hind feet against a branch, seize another with the prehensile tail, and from the strong and widely extended tripodal base so obtained, move the body about with the utmost freedom. The power and flexibility

1 In addition to the quadrupedal marmosets (*Hapalidae*) which have been already described.

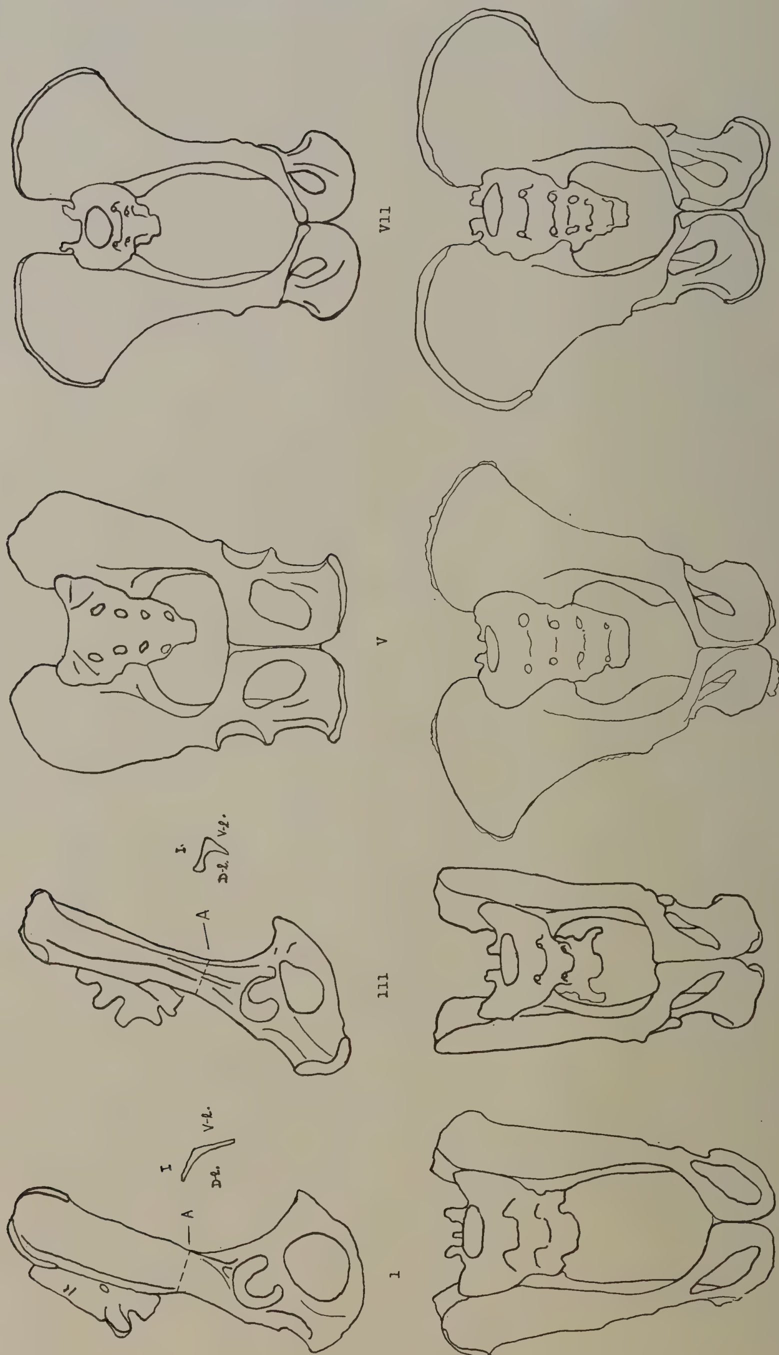


FIGURE 6

FIGURE 6

These pelves have been reduced or enlarged to an approximately uniform size to facilitate comparison. In all, the dotted lines *A* or *B* indicate the position at which the adjoining cross section of the ilium was taken. *I* is opposite the internal surface, *D-l,* the dorso-lateral, *V-l,* the ventro-lateral.

I and II. Cebus (*species uncertain*).

III and IV. Macaque (*Lasiopyga kolbi*).

The contrast between the pelves of a representative specimen of the prehensile tailed Cebinae and one of the preponderantly quadrupedal Cercopithecinae is well shown. Note the relative proportions and directions of the quadrupedal and anthropoidal plates in the two groups. Also the characteristic cercopithecidal tuberosity of the ischium.

V. Gibbon (*Hylobates*). The pelvis is short, broad, and shallow as compared with those of the other Simiidae. The crest is less developed and the shank less differentiated from the blade. The long axes of the ischial tuberosities run almost directly transversely. See also Figure 9.

VI. Orang (*Simia*). The pelvis is broad, short, and deep. The iliac blades and crests are broad, flat, and straight. The ischia are narrow and the acetabula face laterally outwards.

VII. Chimpanzee (*Anthropopithecus*). The iliac blade and shaft are thoroughly differentiated. The crest is well developed and highly curved. The ilia are relatively longer and the lower pelvis shorter than in the other great apes, but a slight difference in the angle from which this illustration was drawn somewhat exaggerates these facts. See also Figure 9.

VIII. Gorilla (*Gorilla gorilla*). The pelvis is broader in proportion to its length; the crests are broad and highly curved; and the ischia are proportionately less wide than in the chimpanzee. Otherwise the pelves are much alike. See Figure 9.

[Figure 6]

of their lumbar regions are especially evident when one of them hangs suspended by the tail with its feet against a vertical surface, and the body and arms extended and moving about in horizontal directions. The reason for the sacral and iliac developments is at once evident. The larger Cebus monkeys indeed possess a degree of this development which is almost equal to that of the gibbon.

The absence of a corresponding degree of ischial and pubic specialization is, of course, due to the fact that these animals in a state of nature probably make but little effort to use their legs in an erect, alternate, bipedal gait.

The trained monkeys of the organ grinders which are usually members of this genus are familiar objects, and we are apt to think of them as erect bipedal animals. Closer observation will immediately show that although the greatly developed spinal processes of their sacro-lumbar region and their fairly large anthropoidal plates allow them to erect and balance the trunk fairly well, they have little power of extension of the thighs. In spite of their very good feet their walk is quite tottering, and it is also to be remembered that even this degree of bipedal progression is not natural to them but is in fact attained only as the result of careful and often prolonged training, while if forced to stand, they commonly adopt a tripodal base (Plate 1). They are at ease and active only in a quadrupedal gait. In a state of nature they probably rise to a bipedal attitude only when reaching for a high object.

The Old World monkeys (*Cercopithecidae*) are divided into two subfamilies, the Cercopithecinae (the baboons and macaques) and the Semnopithecinae (the true monkeys of Africa and Asia). One is at first inclined to think of the Cercopithecinae as terrestrial, and of the Semnopithecinae as arboreal animals, but, in fact, the habits of the two groups are not very radically different.

Though the baboons are preponderantly terrestrial and quadrupedal, they make frequent excursions into the trees, at least when their habitat permits it; while the macaques are rather more arboreal than terrestrial, but use both habits. They both have rather short, subequal legs. They are both, as a whole, heavy animals, are somewhat less active than the Semnopithecinae, and from their weight are necessarily confined to the larger branches.

A trained Cebus in its usual standing position.

The Semnopithecinae, though preponderantly arboreal, make frequent excursions to the ground. They are more lightly built, their pelvic limbs are considerably longer than their pectorals, and they are much more active and varied in their locomotion.

Both subfamilies use a highly developed erect sitting position with great frequency. In that posture they use the fore limbs and paws as arms and hands, and flex and extend their lumbar regions freely and in all directions. When in motion upon the ground, both groups are quadrupedal, and even in the trees the baboons and macaques are essentially so, keeping their femora well within the limits of the quadrupedal position.[1]

Their pelves reflect their habits. In both subfamilies the ilio-ischial axis is straight, and the pubic arm extends from it at nearly a right angle (Figure 5, III and IV), a distinctly quadrupedal and primitive character. The ilium is, however, in them, as in all of the true Anthropoidea, thoroughly specialized and in no sense primitive. In them the quadrupedal plate is broad, and extends, of course, dorso-ventrally, but the anthropoidal plate is about equally broad, extends throughout the entire length of the ilium, and is directed almost exactly laterally. The L shape of the cross section is thus fully evident. In the Semnopithecinae the anthropoidal plate is somewhat more developed than in the Cercopithecinae, as would be expected from the difference in their habits, and it is especially wide in the free end of the ilium. In both, the crest is thickened and well developed.

In the Cercopithecinae the ischium shows a most distinctive cercopithecidal character. The primitive external edge is very strongly developed, and terminates in a very prominent and broad parischial projection. The result is a very large and flat tuberosity of auricular shape, and of wide transverse diameter. In some of them the dorsal edge of the tuberosity also extends backward into a metischial projection. The ischia incline towards each other, and the inner edges of the broad tuberosities lie so closely together that the parturient opening is wholly post-ischial.

In both subfamilies the pubic arm extends well forward (ventrally). In both, the symphysis is long and curved; this last feature being more evident in the Cercopithecinae. In both, the true pelvis is externally wide and also dorso-ventrally deep.

1 So far, at least, as can be judged from observation in the zoos.

It is evident that the ilium, with its wide quadrupedal plate, reflects the fact that these animals are essentially quadrupeds, and that the fairly well developed anthropoidal plate corresponds to their frequent and secure sitting habit. It is noteworthy that the preponderantly terrestrial Cercopithecinae have wider quadrupedal and lesser anthropoidal plates than those of the mainly arboreal Semnopithecinae.

So, too, the great breadth of the ischia, the universal presence of a well developed parischial process, and in many, a metischial, with the strongly ventral projection of the symphysis, reflect their necessity for exertion in varied positions of the hind limbs and with somewhat more than a quadrupedal extension of the femur.

The Simiidae. The pelves of the anthropoid apes show developments of the ordinal, primate pelvis which are of especial interest in as much as they foreshadow the pelvis of man, and, in fact, constitute transitional stages towards it.

The anthropoidal plate widens into a transverse blade unequalled in any of the other animals which have been described.[1]

The ischium, sacrum, and pubes are modified to permit a greater extension of the femur than is necessary to the quadrupeds, and the shape and proportions of the three acetabular arms (the iliac, ischiatic, and pubic axes) distinctly suggest their very peculiar development in man.

The four genera, however, differ widely both in habits and degree of pelvic development. They must consequently be described separately.

Gibbon. The gibbons (*Hylobates*) are highly arboreal animals, brachiators by preference, and from the great interest which attaches to the relations between their pelves and their habits, these must be described with especial care. This description will so far cover the general family peculiarities that the other genera will be chiefly described by comparison therewith.

The gibbons pass the greater part of their lives suspended from their hands and habitually moving among the branches, either by swinging from the grasp of one hand to that of the other, or by swinging leaps in which both hands release their grasp simul-

1 See, however, the appendical note on Bradypus and the Ungulata.

taneously. In either leap the animal is often in unattached motion through the air until a new branch is grasped, frequently for a long distance.

The lateral swinging motions are initiated and maintained exclusively by the arms, the legs being completely flexed, with the knees against the abdomen and the heels against the buttocks. The explanation for the adoption of this attitude of the hind limbs is, probably, that its effect is to raise the position of the center of gravity of the animal as a whole, thereby shortening the pendulum and lessening the moment of inertia against the initiation and increase or decrease of the motion.

The antero-posterior swing is initiated by alternate flexions and extensions of the lumbar regions and legs, much like those used by a human gymnast upon a trapeze.

Hornaday,[1] who has had unusually extended opportunities for watching the gibbon at home, says that when it is at top speed through the branches, the swing which starts from the hands frequently ends in the grasp of the feet, when the animal turns ". . . end over end, catching the branches with his hands and feet alternately."

Even among the branches, the gibbon is not exclusively a brachiator. The writer has several times seen a gibbon run along a horizontal branch for a few feet in a true, alternate, erect bipedal gait. In this progression, they steady themselves, if possible, by grasping other branches with their hands, but for a short distance, nevertheless, they are able to keep their balance when compelled to do so, without any actual brachiation. In such cases, the arms are usually extended and moved about as aids to balance, and the feet undoubtedly aid in it by their grasp upon the branch.

In nature the gibbon lives in the tree tops and his excursions to the ground are probably exceedingly rare.[2] In captivity those which are thoroughly tamed come to the floor of their cages not infrequently. They then move most rapidly and easily in a semi-erect position, by means of an approach to the bipedal gait, but with their arms, which are far longer than their legs, extended, and maintaining their balance by putting the knuckles to the ground, i.e. in a compromise between the bipedal and quadrupedal

1 Hornaday, 1885, *Two Years in the Jungle.* 2 Ibid.

gaits. However, they are capable of moving in a straight line only in a true, alternate, bipedal gait, even upon the ground, and of standing bipedally for brief periods. They have a well developed sitting posture, which is in frequent use.

The ilium (Figure 6, v) shows an advance in specialization over that of any of the lower Primates, but somewhat less than that of the other apes. The shank is somewhat more differentiated from the blade than it is in either the Cebidae or the Cercopithecidae, in which respect it approaches that of the other apes. The blade is wider and the crest is more developed than in the monkeys, but in both respects the gibbon shows much less specialization than the chimpanzee and gorilla. The quadrupedal plate is so greatly decreased that the L shape of the cross section hardly exists, and its long diameter is almost exactly transverse. This evidently corresponds to the fact that they have no complete quadrupedal gait.

The sacrum is narrow, and very narrow on its dorsal as compared with its ventral surface.

The ischia resemble those of the Cercopithecidae and have their peculiarly shaped tuberosities, but their inner ends are so close together that there is no sub-pubic arch, the whole ventral ramus of the ischium taking part in the symphysis. The long axis of the tuberosities is thus turned inward until it is very nearly transverse. The pubes are rather flat, and this absence of the ventral projection which is so constant in the lower anthropoids probably corresponds with the comparative absence of bipedal leaping in the gibbon's habits.

In general shape the pelvis is short and laterally wide as compared with those of the lower Anthropoidea, and shows some approach to the human characters, but from the flat pubis it is rather shallow dorso-ventrally as compared with those of the other Simiidae and also of man.

The most interesting character in this pelvis is a changed relation of the three acetabular arms.

The iliac axis leaves the acetabulum nearly in line with the ischiatic axis, but almost immediately bends dorsally, so that the angle between the remaining and greater part of the iliac and ischiatic axes is considerable (Figure 7, I). This bend is visible externally, but is best seen on the internal surface of the ilium.

It is still better appreciated by palpation along the line of the thickened iliac axis.

This bend in the iliac axis throws both the ischiatic and pubic axes backward, and the direction of the iliac axis thus lies almost directly between the other two. The result is that the three arms form an inverted Y, of which the iliac axis is the tail and the other two are the arms (Figure 2, II).

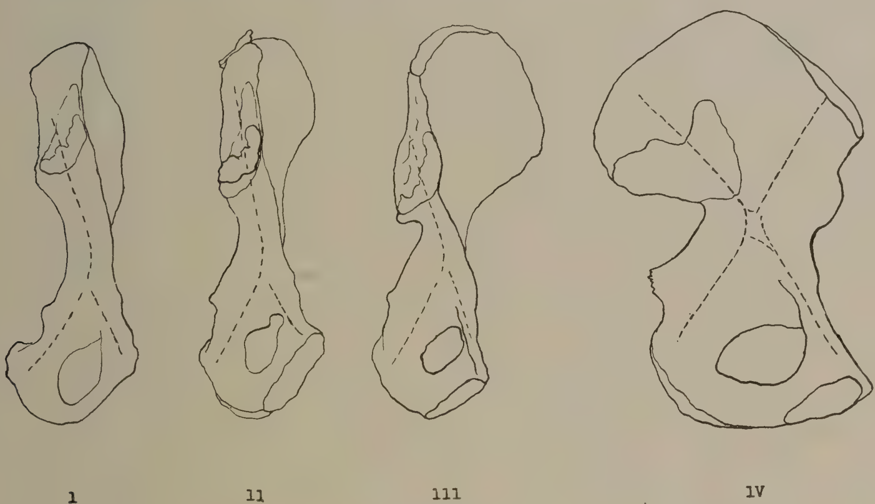


FIGURE 7

I. GIBBON II. CHIMPANZEE
III. GORILLA IV. MAN

The dotted lines show the axes of the pelvic arms in each of the animals.

The complex and varying curves of the pelves make any representation of these axes on a single plane difficult and imperfect. They are much more easily appreciated on the actual specimens, and here again, palpation is the more valuable method of examination. There is a very great individual variation in the amount of the iliac curve within each of the three genera of Simiidae.

Note that in the apes the axis of the auricular surface is directed diagonally downward and backward, and is but slightly curved. In man it is much curved, and its posterior half runs in a direction which, if the iliac axis were straight, woud be backward and upward.

This is a very significant change from the nearly straight ilio-ischiatic axis with the pubic bracket at nearly a right angle to it, which characterizes the quadrupeds and the lower Primates. It is definitely an adaptation favorable to the control of an extended femur and may be regarded as presenting a transitional stage between the quadrupedal innominate and that of man. It is somewhat more highly developed in the chimpanzee and gorilla pelves, but varies much in degree not only in the three genera but also as between individuals in each of them.

These pelvic characters are very closely those which animals of the gibbon's peculiar habits might have been expected to acquire.

As one watches the initiation of the forward swing from both hands, it is very evident that a capacity for complete extensions and flexions of the lower limbs is essential to the rapidity and completeness with which it is executed. It should be noted, too, that at any time when the gibbon hangs by his feet, head downward, his pelvic limb is completely extended; that the action described by Hornaday is evidently facilitated by a capacity for nearly complete extension of the pelvic limbs; and that these frequent necessities for the head down position in the aboreal life of the animal may not improbably be another important factor towards its acquisition of a confirmation which permits it. The ways in which the pelvic developments favor these extensions and flexions are very evident.

The iliac bend has, as has been said, an important evolutionary significance. Its mechanical effect is much the same in kind as that which is produced by the metischial processes and pubic prominence which we have noted in the quadrupedal leapers and diggers, but the method by which this advantage is developed is new and peculiar to the Primates. When it is followed into the higher degrees which are often shown by the chimpanzees and gorillas, it throws a decidedly illuminating light upon the transitional stages which probably existed in the ancestors of man and so preceded the full development of the human pelvic girdle.

The greater development of the crest gives to the pelvio-corporeal muscles of lateral flexion an increase of both power and accuracy of action. The greater expanse of the blade as a whole gives to the glutei both an increase of size and a change in the situation of their origins, which must add much to their efficiency as extensors, abductors, and rotators in the extended positions of the femur. The iliacus flexor also gains in size. The more dorsal situation of the ischial tuberosities, which is due to the bend in the ilio-ischiatic axis, gives to the ham-string muscles, also, greater power over the extending femur.

These many added factors of accuracy of control over the motions of both the trunk and limbs in an extended posture must be all-essential to the speed and direction of the gibbon's wonderful brachiating swings through the branches. These are executed by the arms, but of necessity gain their direction from the changing attitudes of the trunk and legs as the swing starts.

A gibbon in the very large open air cage in the London Zoo was once seen to watch the flight of a bird which had been loosed within it, and then so to time and direct his own swing that he was able to catch the bird in full flight and yet reach the branch toward which his own course through the air was directed as easily as though no such incident had occurred.

On due consideration of the accuracy of the gibbon's arboreal activity, and of the value of complete control of the extended legs in its direction, it seems probable that all these pelvic specializations may have been developed in response to the necessity for speedy, accurate, and extended motions of the hind limbs which is involved in the "trapeze gymnastics" of his brachiating aerial life.

His posture and gait when he uses the bipedal method of progression either upon a branch or on the ground show, upon the other hand, the limitations which are imposed by the very moderate degree to which these developments have advanced.

A gibbon's attitude when standing or walking varies considerably from that which he assumes in his occasional short but rapid bipedal runs, and the two must be studied separately.

In standing or walking the trunk is inclined forward from the buttocks to a much more than human degree,[1] but the back is nearly straight and the head is carried quite well erected. This gives the position of the gibbon quite a human appearance at the first glance. In fact, when standing or walking his position appears as a whole, to a casual observer, to be almost human, but on closer observation it proves to be only a modification of that which is characteristic of the other anthropoids. The lower leg is inclined forward from the ankle to the knee; the knee is rather in advance of the foot; the thighs are sloped strongly backward; and the buttocks are behind the heels. The femora are considerably abducted and the knees are therefore quite wide

1 Some such inclination is of course present in the natural position of most men and of almost all women.

apart. The limb as a whole is then in a far from human position, though it is in a somewhat nearer approach to it than is that of either the chimpanzee or gorilla in either their standing or walking positions. The walk is waddling, as a result of the comparatively wide position of the knees, but not to a very marked extent.

In rapid running upon a flat surface the whole body is strongly inclined forward, the lower limbs are much more extended, the knees are nearer together than in the walk, and the waddle disappears (Plate 2). In this gait he is, however, probably very considerably aided by the inertia of motion, which greatly assists his balance and also lessens the effort of his muscles in supporting his weight. When in this gait he is, however, quite incapable of changing the direction of his run without bringing his hands to the ground.

The difference in attitude between these two gaits is important in its relation to the leverages which his pelvis affords to his pelvio-femoral muscles.

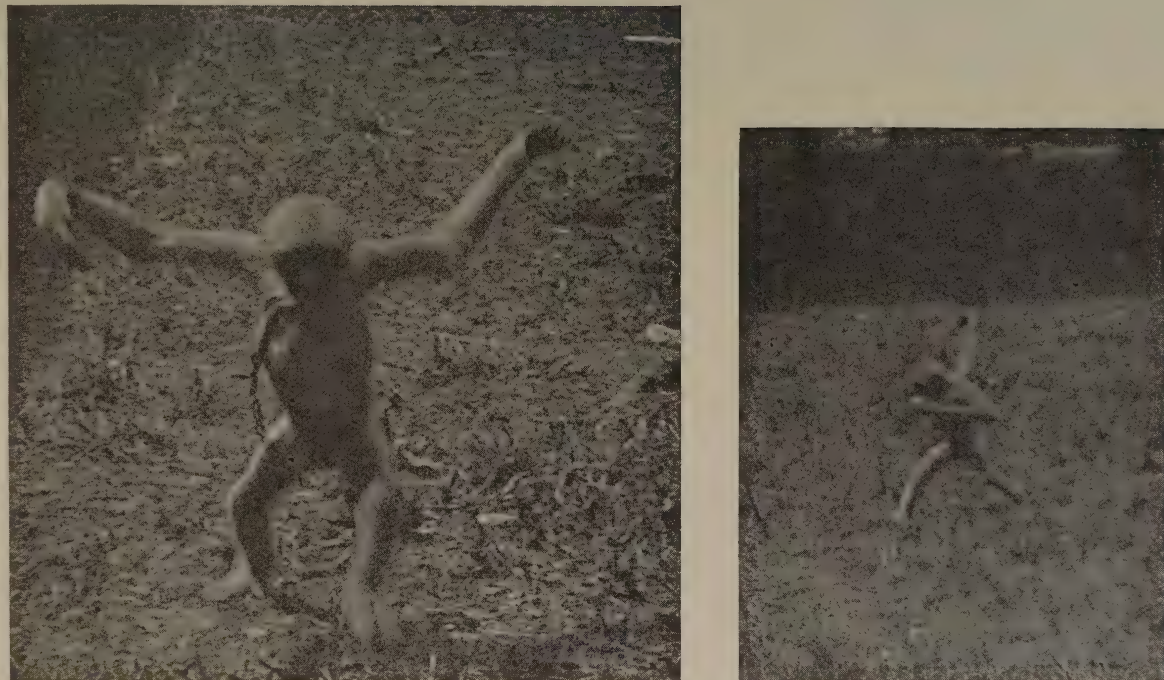
The gibbon's femur is very long, and extremely long as compared to the size of his pelvis. His extensor and other femoral muscles are, therefore, from the shortness of the power arms of the levers, adapted to the production of very rapid motions, but lose in power to a corresponding degree.

His aerial performances show conclusively that their power is quite sufficient to move his legs with speed and great accuracy even when they are in complete extension, so long as only their light weight is to be moved.[1]

His standing and walking attitude, on the other hand, proves that their origin from the very short arms of the levers, which are all that is afforded by the small pelvis and the inverted Y arrangement, makes their power of control over the fully extended femur insufficient for the support of the body in the erect posture and compels him to use the femur in an only partially extended position when standing or walking upon his feet.

The comparatively, but not wholly, complete extension of the legs in the rapid run shows that the smaller amount of force that is needed to hold a rapidly moving object to a straight line permits their use in a somewhat more extended position.

[1] Note that the muscles which control the grasp of his feet have other origins and are full of power.



Enlargements from slow motion photographs taken at the Philadelphia Zoological Garden. The gibbon on the left is at a comparatively slow gait; the one on the right is running fast. The degree of extension of the thigh in each is characteristic.

At either gait the imperfect character of the feet (base of support) is of course important.

As observed in captivity, gibbons vary greatly in the tread of their feet. Of two young gibbons which were studied in the London Zoo and which were closely similar in age, size, and appearance,[1] one walked upon the outer edge of his inturned feet, while the other had the sole on the ground and the hallux widely extended. Similarly an adult white-handed gibbon in the New York Zoological Garden walks upon the fifth metatarsal edge, while an adult of the same species in the Philadelphia Zoo has a completely plantar tread, again with extended hallux. (This last animal seldom walks erect, but runs frequently, and is then very erect.) The variation thus appears to be individual rather than specific, but the feet are very long, and with the inturned tread the digits are curled inward in partial flexion so that the fifth metatarsal and fifth digit are in contact with the ground throughout their length. The feet are carried well apart, and with either tread evidently give a very fair base of support.

The gibbon is a small and extremely lightly built animal, and the fact that it can attain a somewhat more complete, even if occasional and brief, bipedal attitude than the other apes, with a somewhat lesser pelvic development, is evidently a consequence of the all-important law of squares and cubes.

Orang. The orang (*Simia*) is less bipedal in its habits than any other member of this family. It is highly arboreal, and is quadrumanous, grasping the branches or other supports about it with any one of its four extremities, and progressing by the use of any two of them as a pair. It is a heavy animal, and when active, swings and throws itself about in a great variety of actions, during which both groups of pelvic muscles are called upon for active and varied use.

It is a marked peculiarity of this animal that it habitually uses its legs with the femora in a position midway between extension and flexion, but abducted until they are directed laterally outwards. In correspondence to this habit the acetabula open almost directly laterally. Its arms are powerful and are longer than its legs. It is very prone to sustain itself by grasping an upright

[1] They were presumably of the same species, but circumstances prevented the writer from making sure of this.

object with the hand and foot of one side extended laterally, and in this position swings itself about in order to grasp another object with the hand and foot of the opposite side. It uses its hands and feet as grasping organs with equal facility.

Upon a level surface it has, at times, a fairly active quadrupedal gait, but the tread is upon the flexed knuckles of all four hands. Its most characteristic and perhaps most frequent movement across the floor of its cage is from a sitting position with its buttocks as a base. Its hind limbs are then flexed and it swings from spot to spot between its long arms, which are used as if they were crutches.

In a state of nature it probably rarely, if ever, attempts an erect bipedal balance. It is very rarely seen in an erect position in the zoos, though it is just capable of an erect balance and of a few steps in bipedal progression, but with a very peculiar gait.

An immature orang in the London Zoo was, with considerable difficulty, persuaded by its keeper to stand and to walk a few steps under the observation of the writer. In the standing position the lower legs were considerably inclined forward and the thighs were much flexed, the tread was upon the fifth metatarsal edge, but the chief peculiarity of the position was that the thighs were abducted to fully forty-five degrees from the median line. The step was made by carrying the limb which gave the impulse back into a completely lateral position (i.e. by increased abduction), while the advancing leg was merely cleared from the ground; the posterior limb was then brought forward by a swinging motion of adduction; then the process was repeated on the other side. The result was a rather ludicrous and inept waddle.

It has a well developed sitting position.

Its pelvis is broader laterally in proportion to its length than that of any other Primate, except man. It is also deep dorsolaterally (Figure 5, VI).

The ilium has a short shank and an anthropoidal plate which extends almost directly laterally and is marked by great lateral width rather than by length. The crest is straighter, and the blade is consequently more nearly triangular in aspect, when viewed from in front, than in any other of the great apes. The sacrum is also relatively broad and short, and the interlocking processes between the sacrum and the ilium are well developed. The ischium is but little different from that of the Cercopithecidae, though the tuberosities are less flat and broad. The pubis shows a highly marked triangularity of cross section, probably in correspondence to the great strains put upon the adductor muscles in managing the femora in the peculiar abducted position which is characteristic of the animal.

The ilio-ischiatic axis is nearly straight, and the pubic axis is nearly at right angles to it. The metischial process is not prominent, while the parischial is rather large.

In these very important particulars, the orang is alone among the Simiidae in being unspecialized towards any use of the femur in an extended position. This condition, and the lateral expansion of the whole pelvis, the lateral facing of its acetabula, and the parischial development, are evidently specializations towards its peculiar quadrumanous progression. They all evidently afford the best of leverages for lateral flexions of the trunk and for the use of the thigh in an abducted position, and in one which is midway between flexion and extension. The somewhat extreme degree of this peculiar specialization is just what would be expected in so heavy and, at times, extremely active an animal.

Chimpanzee. The chimpanzee (*Anthropopithecus*), a large and heavy animal, is primarily arboreal, but is quite at home upon the ground and is capable of rapid and sustained progress upon its surface. Its gait at such times may be described as semi-quadrupedal, since its arms are decidedly longer than its legs, and the trunk inclines strongly upward from the hips. In this gait the plantar surface of the pes is, at times, wholly in contact with the ground, at times, in its digital portion only, the knuckles only of the hands. The fore limbs thus maintain its balance, and, at most, sustain the weight of the fore part of the animal only, while the hind limbs support most of its weight, and apparently supply practically all of the forward impulse. These conditions evidently demand powerful actions of the legs in a more extended position than would be necessary if the trunk were horizontal, and it should be remembered that the pelvic adaptations which are appropriate to this considerable elevation of the trunk also favor the adoption of an erect bipedal attitude.

As a quadruped the chimpanzee is a very active animal. It is, in fact, preponderantly a quadrupedal animal and as such is evidently quite capable of successful pursuit of food and avoidance of enemies.

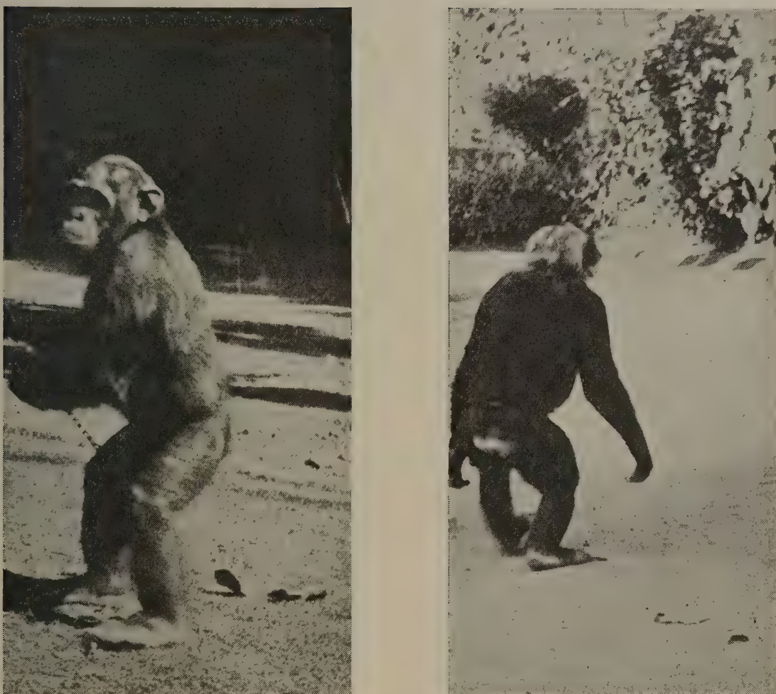
Even when not hurried it usually moves about in this quadrupedal way, but for short distances, and when at ease, it at times uses a semi-erect bipedal gait. The lower leg is then almost exactly erect (Plate 3). The knee is in moderate flexion, and either above or slightly in advance of the foot. The thigh slopes backward from the knee towards the buttocks. The buttocks are well behind the feet, and the trunk inclines forward. The center of gravity is thus above the base of support, but the legs are not columnar, and the posture as a whole is but semi-erect; the knees are wide apart and the gait is waddling, but the balance is fairly well maintained. This is the typical anthropoidal erect attitude as contrasted with the human.

The animal can not only walk bipedally, but since its feet give it a tolerably firm base of support, it maintains a bipedal standing balance fairly well, in the same anthropoidal attitude, however. It has a well developed and thoroughly well balanced sitting position. Its balance is good enough to enable it to use its hands and arms freely when standing, walking, or sitting. It is, however, so far from perfect, that if there is a fixed object within reach, the animal is apt to seize it, or to rest a hand upon it, as it stands or moves about bipedally.

In all of this the form of the foot is, of course, of great importance. That of the chimpanzee, though still, on the whole, of an arboreal type, approaches that of the gorilla and foreshadows the human type, more especially in the character of its midtarsus, and in the strength and development of the hallux.[1] The whole plantar surface of the foot is then in contact with the ground.

The pelvis (Figure 6, VII) reflects the habits of the animal in an interesting way, and especially in its general shape. In the shank of the ilium the anthropoidal plate is somewhat narrower proportionally than in any of the anthropoids previously described, and expands more abruptly as it enters the blade, which is thus more differentiated from the shank than in them. It is much wider in the blade than in any of them, except the orang.

[1] Morton, 1923, *The Evolution of the Human Foot;* and also, Miller, 1920, *Conflicting Views of the Problem of Man's Ancestry.*



Enlargements from motion pictures taken in the gardens of Mme. Abreu in Havana. The chimpanzee at the left is standing; the one on the right is walking. Both attitudes are thoroughly characteristic.

The free ilium is long, and the crest rises in a considerable curve between the anterior and posterior superior spines (consult sub-headings *Gorilla* and *Man*), but on this point there is much individual variation. In some specimens the crest also has a considerable ventral curve, and there is a decided foreshadowing of an iliac fossa. In others there is very little of this.

The sacrum is narrow ventrally, and much narrower on its dorsal surface. This marked difference in the width of the surfaces also appears in the gorilla and man. Its spinous processes are small, but those of the lumbar region are large, strong, and prominent.

The tuberosity of the ischium shows moderately developed metischial and parischial processes.

The pubis is ventrally more prominent than in the gibbon.

In its general shape the pelvis is shorter and broader than it is in the true quadrupeds or lower Anthropoidea, but these changes are much less marked than in man. The bend in the iliac shank which is responsible for the inverted Y arrangement is somewhat more developed (Figure 7, II) than in the gibbon, but it is somewhat less pronounced than in most female gorillas, and much less than is usual in the still heavier male gorilla.

That a somewhat less degree of perfection of the erect habit than that of the gibbon requires a somewhat greater degree of bony specialization in this and the still heavier gorillas again illustrates the importance of the law of squares and cubes.

Gorilla. The gorilla (*Gorilla gorilla*) is much the heaviest of the Primates. One adult male has been reported as weighing more than four hundred and fifty pounds. Its habitat is limited to a few small and, for the most part, rather inaccessible districts in Africa, and even there, its numbers are probably not large. Its habits in its native wilds are but little known, and the best published accounts, those of Akeley and of Barns, are only incidentally concerned with its locomotive habits. Both sexes are described as habitually quadrupedal. Numerous hunters have, however, reported that when the adult male is confronted at close quarters, he rises into a bipedal position and advances bipedally. It seems probable that the female is also capable of this attitude, but no definite statement on this point has been found.

It is believed that the gorilla is primarily a terrestrial animal, though with a habit of making excursions into the trees. The sexes differ greatly in size, weight, and degree of pelvic specializations. Even the females and young are restricted by their weight to the larger branches. None but very young gorillas have ever been captured, and few of them have survived for any length of time. Only two have been accurately observed and reported on, both immature males, under the care of Miss Alyse Cunningham

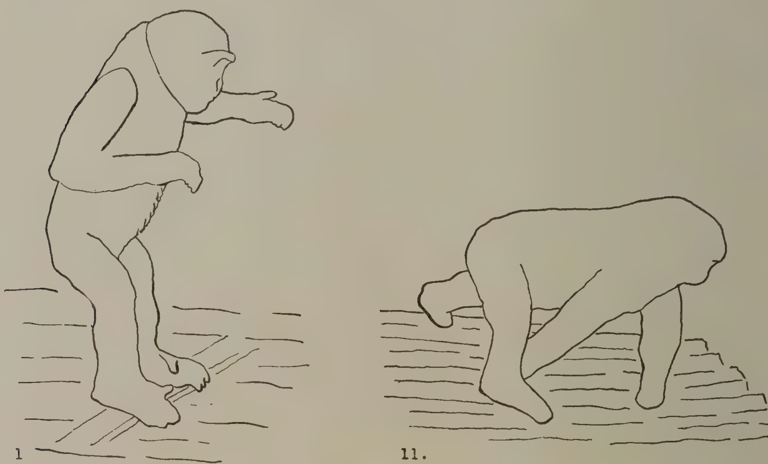


FIGURE 8

Tracings from very indistinct photographs

I. One of Miss Cunningham's young gorillas in a bipedal standing position. It will be seen that one of the feet has an inverted, the other a plantar tread; the same peculiarity has been reported as habitual in some chimpanzees and gibbons.

II. The same animal in a quadrupedal gait.

and Major Penny, in London.[1] Both of them died at the beginning of their second dentition. They were therefore still in the childish stage of life, and not even adolescent, but so little is known of the gaits and attitudes of the adult that those of even these young specimens assume importance (Figure 8). Miss Cunningham has published several accounts of their habits, with photographs, and she and Major Penny have kindly exhibited their collection of photographs and motion pictures to the writer, besides answering many questions. From their account it would

1 See also, Yerkes and Yerkes, 1929, *The Great Apes.*

appear that the habits and gait of the young male gorilla are very closely similar to those of the chimpanzee.[1]

The pelvis of the gorilla (Figure 6, VIII) differs from that of the chimpanzee only in presenting a much more advanced stage of the same specializations. That of the female is frequently distinctly less advanced in each of the peculiar characters than that of the male, and those of the males vary considerably in degree among themselves, chiefly in correspondence with their size, which also varies considerably. In general, the larger the pelvis, the higher the degree of specialization. That of the male will be taken as the type.

In general shape, the lateral width and dorso-ventral depth are greater in proportion to the length than those of the chimpanzee, and in obedience to the law of squares and cubes, the whole pelvis is, of course, more massive proportionally.

The shank of the ilium is shorter; the blade is much wider; the crest is thicker and more developed; its arch from the posterior superior to the anterior superior spine is more pronounced; and its ventral curve is greatly increased, thus forming an internal iliac fossa, which is well marked in all and very pronouncedly developed in most of the larger specimens.

The sacrum is shorter and broader proportionally, and the synchondroses are longer proportionally than in the chimpanzee. The interlocking processes between the iliac and sacral surfaces are often many, prominent, and complicated.

The dorsally directed bend in the iliac axis is usually more pronounced than in the chimpanzee, and in the large males the relationship of its formation to that present in the human pelvis is very clear (Figure 7, III). A beginning development of the tuberosity of the ilium is evident in some specimens. The ilio-ischiatic and ilio-pubic angles are somewhat more acute, and the arms of the inverted Y are thus somewhat more widely separated.

In all these respects, the pelvis of the lighter female occupies, upon the average, a position about midway between those of the chimpanzee and the male gorillas.

The relationship between the pelves of the chimpanzees

1 The skeleton of one of these individuals is in the Museum of The Royal College of Surgeons. The pelvis is characteristically that of a gorilla, but in this connection it should be noted that it is, of course, immature, and its specializations are decidedly less advanced in degree than even those of an adult female.

and gorillas is thus just what would be expected between animals of probably closely similar habits, but widely differing weights.

The comparatively frequent use of the erect attitude by these three genera of the Simiidae, and their acquisition of a fairly useful, true, alternate, bipedal progression may probably be taken as showing that the primate method of developing leverages which give the pelvio-femoral muscles an improved control over the extended femur is an advance over the mere metischial and pubic prominences which have been described as appearing in some true quadrupeds. Their imperfect balance and waddling gaits show that in the degree to which it has been advanced in these anthropoids it is not sufficient for complete success in bipedal progression.

It is, however, an evident transitional step towards the human arrangement which is next to be described, and which was probably also possessed, in some degree, by man's prehuman ancestors. Its conversion into the mechanically more efficient plan of the human pelvis needs only the very easy evolution of one more pelvic arm, or line of strength, and some changes in the general shape of the girdle. These, too, are the more easily comprehended if we remember, first, that the pelves of both the Simiidae and Ursidae are also usually shorter, wider, and of greater antero-posterior depth than those of other quadrupeds, or even of their near relatives; second, that these changes, like the development of the Y, increase proportionally to the degree of frequency and perfection of the erect habit, and to the increasing weights of the animal.

The Hominidae. *Man.* Man is essentially terrestrial and wholly bipedal in his habits. He has entirely lost the quadrupedal activity of his remote ancestors. Bipedally he excels the anthropoids in degree, in the excellence of his balance in the erect posture, in his capacity for standing, walking, and running bipedally for extended periods, and in the rapidity of his erect progression. In his varied bipedal activity he differs from them in kind, and is unique. Man, and man alone, is able to spring in any direction from a bipedal position, and, moreover, he alights from such a spring with a certainty of balance which enables him to repeat it in the same or a different direction. This may seem a small point to insist upon, but this ability to avoid an attack or to pursue a dodging quadruped must not only have been of inestimable value to primeval man, but its development was perhaps in itself the factor which enabled the ancestral anthropoid finally to abandon the quadrupedal gait, and which freed his fore paws for development into the human hand. It is strictly an attribute of man alone, and is dependent not only upon his more perfect foot, but to an equal, or perhaps greater degree upon the extreme specialization of his pelvis.

This will be described here entirely by comparison with those of the other animals.

The human pelvis as a whole is very short and broad (Figure 9, v, vi, and vii). Its external antero-posterior diameter [1] is long in proportion to the total height of the pelvis, and the breadth-height index of the innominates is also high, in comparison with that of the anthropoids and most other mammals.

The innominates, in addition to their high breadth-height index, possess distinctively human characters in their increased curvatures, in the extreme development of the anthropoidal plate, in the greatly bent iliac axis, and in their acquisition of a new and very important development, that of the tuberosity of the ilium and the line of architectural strength which extends between it and the acetabulum.

The specializations of the ilium are perhaps the most striking. The great change in the direction of its axis (Figure 7, iv) must be described first. A full familiarity with this change is essential to any complete comprehension of the pelvic share in the mechanism of the erect posture, and to an understanding of the very complex relations of the anthropoidal plate (which forms the whole iliac blade) to the rest of the pelvis.

Although it can be perceived, especially on the internal surface of the bone, and by palpation, that the iliac axis, i.e. the line which follows the center of the triangular cross section, perhaps shows a trace of leaving the acetabulum in line with the ischiatic axis,[2] its course runs, almost from the start, posteriorly and at almost a right angle to the ischiatic axis (Figure 7, IV).

1 Anterior face of symphysis to end of spinal process of first sacral vertebra.

2 This is often more apparent in the female than in the male.

This is so important a point that something should be said here about the best method of determining it.

In the more primitive pelves the triangularity of the cross section of the ilium is readily apparent. In the more specialized, i.e. in the Simiidae and especially in man, it is less easily recognized by the eye, but even in them it can be clearly appreciated by palpation.

In man the primitive ventral edge is represented by the iliac portion of the ilio-pectineal line, and by the anterior edge of the articular surface which continues it. The primitive dorsal edge forms the border of the iliac portion of the so-called sacro-sciatic notch. The primitive external edge runs, as always, from the anterior inferior to the anterior superior spine. It is the fact that this edge has been carried so far away from the iliac axis and has been turned so far forward by the great development of the anthropoidal plate which obscures the triangularity of cross section in the gorilla and man to the eye of anyone who has not followed the successive steps in its development among the other Anthropoidea. If, however, the thumb of one hand is placed upon the inner surface of the ilium, immediately above the acetabulum, and the thumb and finger of the other hand are applied to the internal and external fossae, as near as possible to the other thumb, the triangularity of cross section in the shank is at once appreciated. Remembering that the auricular surface is always a part of the primitive internal surface, and neglecting the anthropoidal plate, i.e. in these pelves the whole blade, the triangularity of the axis can then be easily followed to the crest.[1]

At first sight it would often seem that in the male the axis was bent upon itself to much more than a right angle, but if it is remembered that the axis, or line of greatest strength, lies in the center of the cross section, it will be evident that the greater narrowing of the sacro-sciatic notch of the male is formed by an excessive flexion of the primitive posterior edge rather than of the axis itself. The position of the true iliac axis varies comparatively little as between the sexes.

The great width of the blade is due to the high degree of development of the anthropoidal plate, which extends from the retro-

[1] In other words, tracing out the primitive external edge by the base line of the anthropoidal plate.

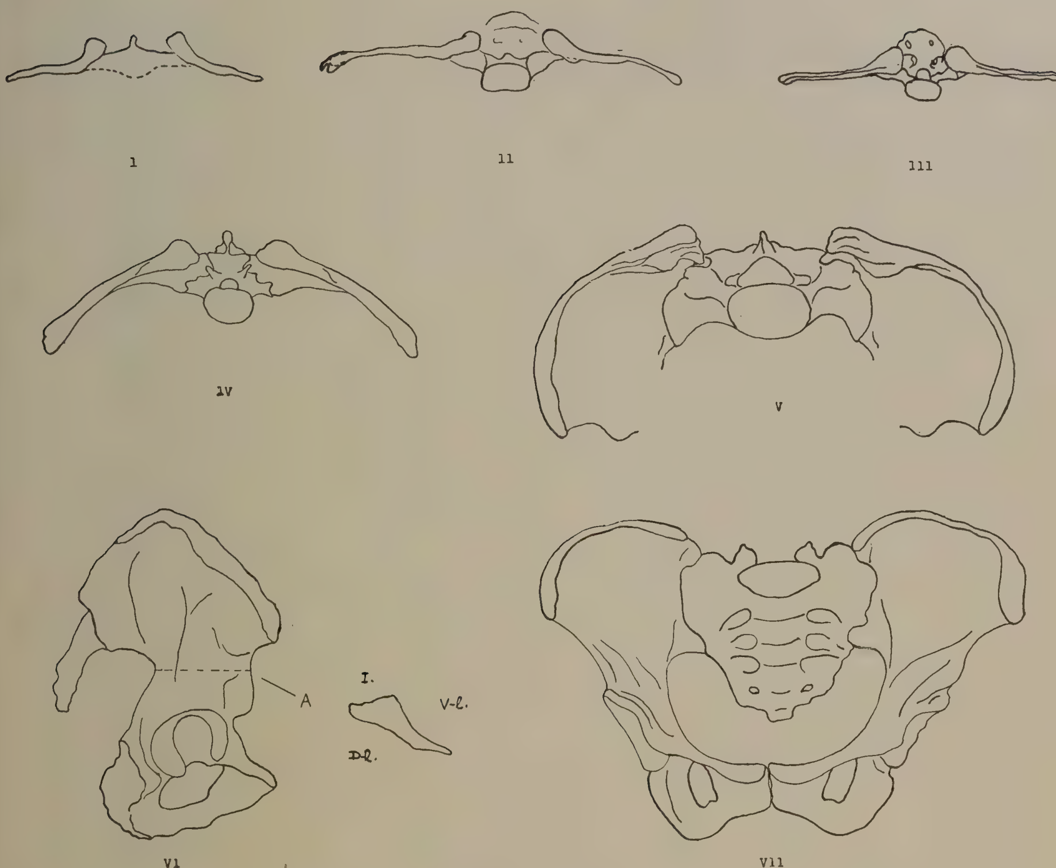


FIGURE 9

I. GIBBON
II. ORANG
III. CHIMPANZEE
IV. GORILLA
V. MAN
VI. MAN
VII. MAN

Bilateral asymmetry is almost the rule in the pelves of the Simiidae. That it is the left ilium that is narrow in all the first three figures is a mere coincidence.

I. The sacrum is incompletely shown as the drawing was made from an articulated specimen and most of the sacrum was hidden from the camera lucida.

flexed iliac axis to the anterior spines. Its great extent, however, is due rather more to the backward flexion of the axis than to the anterior position of the spines, although they are, in fact, situated much further forward than in the anthropoids. It must be understood, too, that its expansion is fan-like, i.e. that its lines of cross section radiate from the curved axis, starting always at right angles to the axis and therefore radiating apart from each other as they proceed towards the crest.

The crest is greatly developed, thickened, strengthened, and increased in width. It shows in full degree the S curve which is due to the development of the internal and external iliac fossae and which in developed form is a human attribute, although it is foreshadowed in the Simiidae (Figure 9) and appears in some ungulates (see Appendix). As a result of this curve the bi-spinal diameter is always less than the greatest bi-iliac, which is typically, though by no means always, between the tuberosities. The anterior inferior spine has been shifted forward and inward along the edge of the acetabulum and is directed almost exactly anteriorly, whereas in the quadrupeds it is external and is directed laterally, and in the Simiidae it occupies an intermediate position.

The tuberosity of the ilium is distinctively a human characteristic, although, as has been said, a beginning tuberosity is perceptible in many male gorillas. Palpation will show in all cases that the ilium is thickened along a line running from the acetabulum to the tuberosity, but this thickness and also increase of strength often persists in partial degree across that segment of the blade which lies between its greatest development in the acetabulo-tuberous line and the anterior spines.

The ischium as a whole is short, and its shank is very short. The tuberosity runs up nearly to the edge of the acetabulum and its surface for muscular attachments is largely on the posterior aspect of the ischium. The spine of the ischium is greatly developed, in correspondence to the extremely important function of the great sacro-sciatic ligaments in the attitude and gait of man.

In the ischium of even the most specialized pelves the triangularity is apparent to the eye. The primitive dorsal edge is easily identified by the spine of the ischium which projects from it, the anterior (primitive ventral) edge is in the obturator foramen, and the external edge runs from the acetabulum to the tuberosity.

The acetabular ramus of the pubis is strong and has a much more fully developed triangularity of cross section than in the anthropoids, although it is in them more easily recognized on account of the less complex shape of the ramus.

This triangularity in the pubes is rare and is limited to small groups in the other orders. The edge of the foramen corresponds to the primitive dorsal and the pectineal line is the primitive ventral edge. The external runs from the acetabular opening to the spine of the pubis. The symphysis is short and broad.

The sacrum is extremely broad in proportion to its length but its external or posterior surface is narrow as compared with the internal. Its spinous processes are much reduced in prominence, and the arches may even be diastemic. It is distinguished from other sacra by the great antero-posterior depth of the first vertebra, which, with a similar condition in the fifth lumbar, forms the promontory.

The mechanical relations which are dependent upon these altered proportions of the human pelvis are of great interest. They must be considered both from the norma lateralis and norma verticalis, and in their relation to the pelvio-femoral and to the pelvio-corporeal muscles.

The direction of the sacral axis is thrown considerably backward by the formation of the promontory and lumbar curve. This combines with the bend in the iliac axis to throw the ischium also backward, and places the tuberosity of the ischium in a posterior position which could otherwise be obtained only by a long metischial process.[1] The pubis is also, of course, rotated down-

1 The effect of these changes upon the sacro-iliac synchondrosis is very interesting. In primitive pelves the iliac surface of the synchondrosis runs along the primitive internal surface cephalo-caudally, or at most, slightly cephalo-dorsally. In the more specialized quadrupeds the angle of its direction varies considerably, but it runs, in general, in a cephalo-dorsal direction.

In the Simiidae its upper (i.e. cephalad) part runs cephalo-caudally along the primitive ventral edge (Plate 1), but the lower part turns to run cephalo-dorsally across the primitive internal surface to the primitive dorsal edge.

In man the upper part runs in the primitive direction (i.e. in that which with a straight axis would be cephalo-caudal) along the primitive ventral edge, while the lower part has increased the curve and change of direction which exists in the Simiidae so greatly that, after crossing to the primitive dorsal edge, it often ends by running along that edge in a direction which is the reverse of the primitive, i.e. caudo-cephalad.

The writer believes that this change has a probable bearing on the conflict between the ward, and the anterior superior spines of the ilium are thrown forward.

The position assumed by the whole pelvis in the erect position varies considerably in different individuals and its mean has never been satisfactorily determined for either sex, but the conventional position, in which the pubis and the anterior superior spines of the ilium are in the same vertical plane, will be assumed for the purposes of this paper as approximately correct.[1]

The changes in the constructional architecture of the innominates which follow these changes of shape and direction are also important.

It will be remembered that in the more primitive mammals the architectural strength of the pelvis is mainly concentrated in the approximately straight ilio-ischiatic axis, with the average position of the femur at about a right angle thereto (Figure 3); also that in the Simiidae the chief lines of strength are distributed in somewhat the shape of an inverted Y, and with the line of the femur between the tails of the Y. In the human pelvis the appearance of the new acetabulo-tuberous line of strength and the much increased bend in the iliac axis give to the architecture of the pelvis a mechanical construction which may be fairly represented by an X with its arms very nearly at right angles and with the line of force of the extended femur lying between the lower arms of the X[2] (Figures 2 and 7).

When viewed from the norma lateralis, it may perhaps be more satisfactorily compared to a wheel, with the acetabulum then representing the hub; the four pelvic arms or lines of strength, the spokes; while the iliac crest, the pubo-ischiatic ramus, the

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pelvic part in the mechanism of the erect position and the necessary provisions for the parturient process, but it is not possible to enter into the question of the relations of the pelvis to labor within the limits of this article. All that can be said here is that conditions in the Hominidae make it necessary that the sacro-iliac articulation should be very firm, and at the same time capable of adaptation to parturition.

1 From X-ray studies in the erect posture which the writer has made, but which are not yet ready for publication, it seems probable that this position is sufficiently near the average to warrant the general statements which will be made in the text.

2 The mechanical effect of the femur considered as a supporting structure is, of course, exerted in a straight line between the bearing surfaces of its head and condyles. In the general statements to be made here its action in the flexions and extensions may fairly be considered as though it were, in truth, straight. The small allowances which should be made for the effect of couples upon the action of individual muscles or groups may be neglected. In the movements of rotation of the limb the effect exerted by the existence of the neck is, however, all-important, but will be self-evident.

sacrum, and the ligaments which fill in the gaps may be considered as the rim.[1] The thinner sheets of bone and the fasciae fill in the spaces between the spokes and bind the whole structure together.

The lengths of the power arms of the levers which this arrangement gives to the muscles that govern the antero-posterior movements of the extended femur (Figure 3) should be especially noted. It should also be remembered that these advantages in leverage apply equally well to the similar movements of the pelvis upon the femur, in the management of the positions of the trunk.

When the human pelvis is viewed from the norma verticalis the contrast which it offers to those of the Simiidae is again great (Figure 8).

The great extent of the human anthropoidal plate and its crest, with the forward and even inward curvature which the crest shows as it nears the anterior superior spine, is particularly important.

It will be seen later that these changes give to the pelvio-corporeal muscles greatly extended origins and constantly increased power, as well as very direct action. From a mechanical standpoint the crests are continued to the pubes by Poupart's ligaments; and both the great lateral width and the antero-posterior depth, which this whole arrangement gives to the upper edge of the pelvis, are equally noteworthy.

The mechanical advantages which these various changes in the shape, dimensions, and construction of the human pelvis give to both the pelvio-femoral and pelvio-corporeal muscles will now be discussed in detail and in order, as a necessary preliminary to an analysis of the human balance and gait.

The relationship of the altered shape of the human pelvis to the management of the extended femur in the movements of extension, flexion, abduction, adduction, and rotation will be taken first. The similar movements of the trunk will follow.

Since, however, a discussion of the action of each muscle would involve a very great complexity and a great amount of space, they will be treated in the text merely from the aspect of

1 As attachments for muscles, the sacro-sciatic and Poupart's ligaments are quite as satisfactory as bone, more especially since Poupart's ligament is reinforced by the inguinal fascia and Gimbernat's ligament. Some initial trace of Poupart's ligament is also present in the gorilla. Keith, 1923, *Posture of Man.*

their resultants as groups, rather than as single muscles. References to individual muscles will, as a rule, be given in footnotes.

The group of muscles which extend the femur arise mainly from the ischiatic spokes and from the rim and surface of the posterior quadrant of the wheel, as seen from the norma lateralis. Each of them evidently gains power over the extended femur from the (human) dorsal situation of its origin.[1]

The flexor muscles differ somewhat in the situations of their origins, but depend for the most part upon the position of the pubic spoke. They gain similar advantages from the great antero-posterior depth of the pelvis and from the forward rotation of the free ilium.[2]

Abduction of the thigh is chiefly performed by the glutei medius and minimus. From the great lateral expansion of the iliac blade in man their origins lie, in him, directly above their insertions into the great trochanter, and this gives them a very direct abductive action as compared with that of the apes. Their size also increases from the increased space afforded for their origins. They are still small muscles, but the greatest importance of the motion of abduction is perhaps that of placing the limb in position for the action of the extensors in man's lateral spring, and for that, no more powerful group is needed.

The adductors gain power from the widely lateral situation of the human acetabula. This is of real importance in many of our activities and chiefly perhaps in their contribution to the very

1 In particular, the backward position of the sacrum and, consequently, of the sacro-sciatic ligaments, gives great power and a direct backward pull to the gluteus maximus, and the position of the origins of the hamstrings on the posterior surface of the posteriorly situated ischium gives to these muscles also an advantage towards complete extension of the femur, which is distinctively human.

2 The forward position of the anterior superior spines of the ilium, which they obtain both from the forward extension of the crest and from the promontorial rotation of the pelvis as a whole, gives to the sartorius a long power arm for its flexor action upon the extended femur. This the much more powerful sartorius of the quadrupeds entirely lacks, as a result of the merely lateral position of their anterior superior spines and the consequent lack of any anteriorly directed power arm when the femur is fully extended. The great psoas-iliacus flexor runs, after passing in front of the pectineal eminence, strongly backward to its insertion in the femur. The forward position of the pubis which is derived from the great length of the external sagittal diameter gives to the adductor group of muscles which are attached to it a degree of flexor power which is again distinctively human; i.e. with the abductor muscles and those of external rotation in resistance, the great adductor group, and especially the adductor magnus, exerts upon the extended femur in man an extremely powerful flexor action which is comparatively slight in other animals.

important lateral flexions of the whole structure, which are essential to balance, as will be seen.

External rotation of the thigh is a movement of much more importance than is usually attributed to it, as will be seen in the analysis of the gait of man. All the muscles which effect it are inserted upon the great trochanter, or its immediate neighborhood, and consequently depend for their power upon the fact that the position of the trochanter is well to the outside of the line of rotation of the femur, the straight line between the bearing surfaces of its head and condyles, but they obtain their very direct action upon the trochanter in man from the fact that their origins are carried far posterior by the backward positions of the ischium and sacrum.[1]

It will be seen that internal rotation of the thigh is in the gait of man merely a movement of recovery of the position of the limb unapposed by any load. Its muscles require no great power and need not be enumerated here.

In studying the mechanical advantages which the peculiarities of the human pelvis give to man in the very important matter of the balance of the erect trunk upon the pelvis as controlled by the pelvio-corporeal muscles, we must also consider the pelvic shape from the norma verticalis, or perhaps for the moment, from the plane of the superior strait. It will then be seen that the crests and their ligamentous extensions form a complete oval for the attachment of the muscles which control the trunk. Compare their human and anthropoid shapes (Figure 9).

The antero-posterior extensions and flexions, the lateral extensions and flexions, and the torsions of the trunk upon the pelvis will be considered in that order.

The pelvio-corporeal extensors of the trunk obtain a great advantage from the formation of the promontory and the lumbar curve. They have, indeed, a quite different mechanical action in man from that which they exert in the other animals, more especially in their effect upon the lumbar and dorsal spine.

1 This motion is performed by a large group of powerful muscles. The lower portion of the gluteus maximus and the posterior fibres of the medius and even of the minimus play a considerable part in it, while the pyriformis, obturator internus, both gemelli, and the quadratus femoris have this as their main function. (Note that even in the case of the obturator and gemelli the direction of the strain is determined by the position of the ischium.)

In all the animals with posterior convexities of the lumbar spine and comparatively straight sacra, the leverage from which the muscles obtain their power is derived mainly from their origins and insertions upon the long and strong spinous processes of the sacral and lumbar vertebrae, which act as strong power arms in tilting the vertebrae. In man the lumbar concavity, increased as it is by the backward direction of the sacrum, gives to the erector spinae group somewhat the action of a bowstring. It is true that the erector spinae group as a whole is bound down to the lumbar curve by fascia, but the effect of this transverse binding is closely comparable to that of the annular ligament in the wrist. It makes for compactness and does not greatly diminish the resultant power exerted by the whole muscle from that which would exist if it ran straight across the concavity upon which it acts.[1] The spinous processes of the lumbar vertebrae persist and are still advantageous to the deeper fibres, but the great and strong sacral spinous processes which exist in so many of the other animals are no longer necessary, their function being taken up by the bowstring action. They are in man evidently involuting.[2]

Since even in the erect position the center of gravity of the trunk is always anterior to the acetabula, the anterior flexions are usually assisted by gravity. The muscles which perform them are a powerful group in all the other animals, and are but little altered in their action in man.[3]

The muscles which effect lateral flexions of the trunk originate wholly, or in part, from the crests of the ilia and gain long power arms from the great lateral expansion of the crests,[4] but

1 It must be remembered that the sacro-spinalis, the longissimus dorsi, and, in fact, all the superficial portions of the muscle run from end to end of the concavity.

2 In many sacra those of the upper vertebrae are still present in size sufficient to suggest some functional value, but the spinous processes of the lower vertebrae are rarely prominent, and often vestigial; their entire disappearance and a diastemic condition of the arches at either end, or even throughout, is indeed not uncommon. This condition may probably be regarded as representing merely an excess in the variability which is so common in all involuting organs.

3 The recti abdominis originate from the crests of the pubes, and in so far as their action is concerned, the greater antero-posterior depth of the human pelvis is probably about compensated for by the backward rotation of the pubis, which is produced by the formation of the promontory and lumbar curve. They are assisted by the middle fibres of the external obliques, which originate from the inner lips of the crests at about the tuberosities, and when employed bilaterally exert together a moderate amount of flexor action. They undoubtedly do obtain some advantage from the forward extension of the crests.

4 When one erector spinae is in relaxation and the other in contraction they are, of

it will be seen later that in any erect bipedal position these very frequent and important adjustments of attitude usually involve coördinate and simultaneous action of the trunk and femurs. In the lateral flexions of the body as a whole, the motion of one femur is of course that of abduction; of the other, that of adduction.

When this whole process is considered as one action it will be seen that a large proportion of the muscular force which produces it [1] originates in the neighborhood of the acetabulo-tuberous line of strength, which has probably been developed partly in resistance to the stresses so exerted.

All the pelvio-corporeal muscles are, of course, bilaterally duplicated, and the varying torsions of the trunk, which are frequent and necessary elements of balance in many of man's erect bipedal activities, are effected by contraction of one muscle of each pair with simultaneous relaxation of the other.[2]

A very little reconsideration of the preceding paragraphs will readily show that all the muscles which are involved in these combined movements obtain important mechanical advantages from their attachment to the strongly constructed, widespread, and, with the ligaments, completed oval of the upper rim of the human pelvis, as seen from the norma verticalis. It is the perfect control of lateral balance that is so obtained which gives man the power to stand, walk, and run with his knees and feet close together, and with, in consequence, the great advantage of a directly antero-posterior movement of his legs in walking and running.

A comparative analysis of the bipedal attitude and gait of man and the great apes in the light of observed facts about bipedal balance is the final step in estimating the importance of the human pelvic specializations.

The writer's studies of balance have shown that there is a considerable difference in the position of the human center of gravity in different individuals in the standing position, but that each in-

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course, acting as muscles of lateral flexion, but their most powerful portions for this action are to be found in the longissimi dorsi, which, in man, arise from the posterior parts of the crests. The quadratus lumborum and external oblique also arise from the crests and exert a direct action both in the maintenance of lateral equilibrium and in the production of lateral flexion.

1 That of the abdominal obliques and of the abductors of the femur.

2 The latissimi dorsi and the obliques of the abdominal wall are probably the chief factors in torsion of the trunk upon the pelvis, but the action of some of the deeper portions of the erectores spinae must not be forgotten.

dividual tends to maintain his individual position of the center of gravity with a surprising degree of exactitude, in spite of the assumption of many different attitudes (Figure 10).[1] When any change of attitude carries a portion of the body further to one

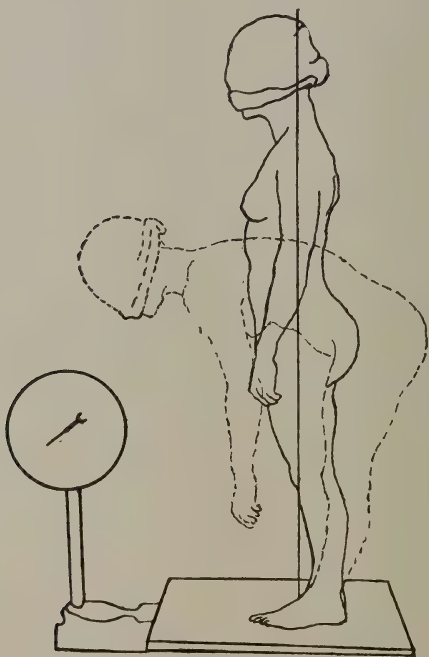

FIGURE 10

The subject stands on a machine which indicates the position of the centre of gravity, here indicated by the vertical line. The figure is reproduced from a composite photograph in which the needle of the dial was at the same point, i.e., actually in single outline, in the two postures.

side of the perpendicular dropped from the habitual center of gravity, another portion of the body is always carried to the opposite side to a distance just sufficient to maintain the center in the same position. The movement of the buttocks backward in compensation of the forward position of the head and shoulders

[1] Reynolds and Lovett, 1909, *A Method of Determining the Position of the Centre of Gravity in its Relation to Certain Bony Landmarks in the Erect Position;* also, 1910, *An Experimental Study of Certain Phases of Chronic Backache,* pp. 1033–1043.

is shown in the figure. Anyone can easily observe the effect of lateral flexion in his own person. If he will stand between a mirror and any vertical line, such as the edge of a door casing, and will then flex his body laterally, he will see that his hips are always thrown to the left as the head and shoulders move to the right, or vice versa. He will easily be able to judge that the movement is exactly compensatory, as it has in fact been shown to be by many observations upon the machine. This must be borne in mind throughout all comparisons of the attitudes of the apes and man.

When any animal other than man attempts a bipedal attitude or gait, its feet and knees are held wide apart, its hind limbs are in partial flexion throughout, its buttocks are well behind, and its head and shoulders correspondingly in advance of the vertical position of the center of gravity, which in the standing position of any animal is undoubtedly kept at a point not far from the center of its base of support. There are two reasons for its restriction to this imperfectly erect posture.

In the first place, the lateral spread of the feet and knees widens the base of support and makes lateral balance easy. The animal is thus able to maintain it and even to execute lateral swaying motions without overdoing them, in spite of the imperfect leverages and the small size of the attachments which are afforded to the muscles governing these movements by its comparatively ill developed anthropoidal plate.

In the second place, it is forced to adhere to a semi-erect antero-posterior position by the fact that this is the nearest approach to an erect posture in which the muscles attached to its pelvis have effective control of the femur under either the quadrupedal or semi-quadrupedal (anthropoidal) arrangements of the pelvic architecture.[1]

The walking gait of all such animals is rendered waddling, awkward, and ineffective by two factors which are due to this attitude; first, the widely separated position of the feet compels it at each step to sway the body strongly towards the foot which is to remain on the ground before raising the other, in order to avoid a lateral fall; second, for the same reason, the advancing

[1] Sonntag, in *The Morphology and Evolution of the Apes and Man,* thinks that the wide fascial attachments of certain of the posterior muscles of the thigh probably also limit extension at the knee in the chimpanzee and gorilla.

knee must move in the arc of a circle instead of in an antero-posterior line. These are the characteristics of the gait which belongs to the anthropoid stage of pelvic advancement.

Man has developed a pelvis with leverages which permit him to manage his legs accurately in a position of full extension. His legs have become straight and columnar. His pelvic leverages, as already enumerated, are sufficiently developed to give him also a quick and accurate control of the fully erected trunk upon the pelvis. He stands, walks, and runs with his feet and knees close together, with his body swaying but little laterally, and with all the force of his muscles available for an almost directly antero-posterior stride.

He is also able to change the direction of his run at any moment from a bipedal attitude, and he is capable of either an antero-posterior or lateral leap, during which both feet are clear of the ground. These are powers which are not possessed by any anthropoid.

His ability to do all this with so high a center of gravity and so small a base of support is in part due to his better control of body balance, and in part to his improved feet, which will be referred to later.

In his standing attitude the center of gravity of his trunk is, as has been said, anterior to the acetabula, and his maintenance of body balance must therefore be maintained by some tension upon the extensors. His weight is, however, sustained by a direct thrust upon the bones of his columnar legs, and this with the very nearly erect position of his trunk reduces to a minimum the force which is required to maintain the attitude. Moreover, the long power arms which are supplied to the extensor muscles of both his back and thigh by his pelvic developments and patella enable the extensor muscles to supply this minimum of force with a second minimum of contractile effort in either the body or thigh; hence his easy endurance of this position.

His rapid bipedal locomotion, his ability to change its direction, and his lateral spring are all greatly aided by the large size and advantageous situation of the group of muscles which govern and produce the motion of external rotation of the femur. The value and relationships of this very important motion have been much underestimated. They must now be considered in detail.

The chief element in bipedal progression is, of course, furnished by the extensors of the whole limb, but in man at full speed the stride finishes and obtains its final and crowning impetus of force by a combined movement of external rotation of the straightened limb and of extension of the foot.

In change of direction of the run, and in the lateral spring, the center of gravity is shifted towards the new direction by lateral flexion of the trunk (quick and powerful pelvio-corporeal muscles), and the leg from which the lateral movement is to originate reaches the ground in flexion and in a position of abduction (from the acetabular joint). This element in the action of the limb is of extreme importance. The extensors of the thigh and leg are then, of course, the chief agents in the subsequent spring, but from the early moment at which the heel leaves the ground, at the beginning of the spring, the action of the muscles of external rotation become not only essential to its continuance, but an important element in its force and speed.

A single experiment with the lateral spring in his own person will convince anyone of the importance of the combined movement of external rotation and extension of the foot in this all-important action.

Conceive primeval man in the act of receiving the charge of a dangerous animal or pursuing agile prey, and without effective missile weapons.

Two facts about this combined movement remain for consideration.

It is of value to either antero-posterior or lateral progression only when the limb is wholly, or nearly extended, and chiefly when it is synchronous with extension of the ankle.[1]

The spring which initiates lateral movement, either in the run or from a standing position, is, of necessity, always executed with the limb in an abducted position. In this position of the limb the hallux and first metatarsal are the only portion of the foot which are in contact with the ground, and the spring is taken from them alone.

It seems probable, then, that these several human character-

1 A little thought will show that in the flexed position of the limb the rotational power of the muscles is at a minimum, but any attempt at a full exposition of the action and interaction of even a few of the muscular groups which are involved in the maintenance of the erect position and gait would require a large volume for its expression.

istics, namely, the pelvic changes which give power to the extensors and external rotators, the columnar legs, and the peculiar position, length, and strength of the first metatarsal, occurred contemporaneously, and by synchronous stages of development.

It seems probable, too, that they occurred at a time which was antecedent to the specializations for grasping which characterize [1] the feet of all the existing Simiidae.[2]

The study of the development of the human foot is not strictly germane to the subject of this paper, but since the pelvic developments may have some bearing upon the vexed question of the relationship between man and the several genera of the anthropoid apes, it seems proper that the paper should not be closed without some reference to that subject.

The chimpanzee-gorilla stem is generally considered to be nearest that of the Hominidae, but the apparently much, and really somewhat more perfect, erect gait of the gibbon, in combination perhaps with the characteristics of the Pithecanthropus femur, have led some authorities to a belief that the common ancestor was probably a very large gibbon, or more properly, a large gibbon-like animal.

It is the writer's belief that all the locomotive skeletal specializations of the gibbon can be traced to his assumption of a very active arboreal life among the smaller branches, for which small size and light weight are absolutely essential, and to his acquirement of the capacity for quite complete extension of both the trunk and limbs which has been incidental to his brachiating habits.

It seems quite unlikely, on the one hand, that complete brachiation and the development of the specializations towards extension which are appropriate to it could have been attained by an animal whose greater weight limited him to the lower branches. On the other hand, it is at least equally improbable that an animal which had acquired security from enemies and success in the pursuit of food by the development of great brachial activity

1 Miller, 1920, *Conflicting Views on the Problem of Man's Ancestry.*

2 With the widely separated position of the first metatarsal which exists in the gorilla, in the chimpanzee, and to a less extent in the gibbon, a lateral spring from the position of the foot which is incidental to the abducted position of a straight limb would be ineffective, if not painful, and the rotation of the femur would have little or no value, even if full extension of the leg had become possible.

among the upper branches would ever be led to resort habitually to the more dangerous terrestrial life, or to undergo a giantism which would shut him out from the habitat in which he is so conspicuously successful. When all the other differences between the gibbon and man are taken into account their common ancestry becomes probably very remote.

On the other hand, the existing chimpanzees and gorillas have obtained about the same degree of pelvic development and bipedal capacity as a result of their long arms and semi-quadrupedal terrestrial activity. An ancestor common to them and man would be as well equipped for the development of further bipedal activity as any gibbon-like animal. He would probably be already large enough to be restricted to the larger branches, which afford far less food than is accessible to the lighter arboreal animals. He would therefore be likely to be at least partly terrestrial in his habits, from his semi-quadrupedal activity would have already acquired about the same degree of pelvic and locomotive development, and would be already quite capable of taking care of himself upon the ground.

CONCLUSIONS

In conclusion the writer thinks:

1. That a capacity for habitual erection of the trunk, even upon a stationary base of support, is dependent upon a lateral expansion of the iliac blades such as is provided by the anthropoidal plate. This plate, or its equivalent, is, in fact, present in all animals which have such a habit.

2. That a capacity for habitual alternate, erect, bipedal progresssion is dependent upon the possession of a plantar tread, a well developed anthropoidal plate, and, in addition, a power of using the femur in an extended position. Further, that the extension of the femur and its adequate control in that position is primarily dependent on the additional development of advantageous leverages in the ischium and pubes.

3. That the degree of bipedal progression which is possessed by the Simiidae and certain Ursidae is afforded to them by their acquisition of a moderately well developed set of the above mentioned specializations, but is limited by their retention of the quadrupedal, long, and nearly straight ilio-ischiatic axis and the quadrupedal length-breadth-depth proportions of the pelvis, which are necessary to their preponderantly quadrupedal habits.

4. That man's general bipedal activity is dependent on his well developed plantar feet, his excellent control of the antero-posterior and lateral balance of his erected trunk, and his very perfect control of his pelvic limbs when they are in a position of complete extension. Further, that these latter superiorities of man are due to the fact that the changes in the shape and proportions of his pelvis have resulted in placing its most advantageous leverages in resultants of position, which lie at right angles to the axis of his trunk and to that of his fully extended legs (Figure 3), in contrast to the quadrupedal arrangement, in which the best pelvic leverages lie very nearly in the lateral plane which contains the axis of the trunk.

5. That the individual specializations of the human pelvis conform exceedingly well to the muscular origins and insertions which are necessary to the maintenance of erect balance and to erect bipedal activity. Further, that they are satisfactorily explained thereby.

6. That all of the specializations which have produced these results can be traced back to the primitive through intermediate stages, by the method of attributing all specializations to the development of plates and other processes from the three primitive edges. That the shape of each change has of course been determined in each case by strict obedience to the demands of mechanical law, and that their comparative perfection is an inevitable and necessary consequence of this fact.

APPENDIX

THE PELVES OF BRADYPUS AND THE UNGULATES

Bradypus (Figure 2), which from its peculiar habits makes very small demands upon its pelvis, has an ilium which, in the breadth of its blade and the evident method of its development, strongly suggests that of an animal which makes frequent use of the erect posture. The fact that an animal which never sustains its weight in an ordinary way, but passes its life suspended, should have such an ilium would be unexplained and would throw doubt upon the entire hypothesis, if the answer were not supplied by the palaeontological evidence.

Many of the ground sloths were enormously heavy animals which must have passed much of their time in a semi-erect posture, and in reaching their food must have constantly swayed their enormous weight back and forth and from side to side upon the base formed by their hind legs and tail, with the pelvis mechanically, perhaps, the most important factor in the machinery by which these movements were performed. Their ischia, pubes, and sacrum are edentate in form and are unmodified. The femur is short; the caudal vertebrae are furnished with large chevron bones; and the tripodal base must have been formed in the usual tripodal manner, with the femora in the quadrupedal position, and the powerful tail extended backward. In exact accordance with what would be expected from the principles laid down in the text, their ilia have, however, large anthropoidal plates of great lateral extension, and even curve ventrally as they approach the anterior superior spines, in a way which strikingly suggests those of man.

In comparing the pelvis of Bradypus with them it is evident that though it resembles those of its extinct relatives in every taxonomic character, it has, in the extreme tenuity of the bones, even for an animal of its weight, in the absence of the ridges and roughened surfaces for muscular attachments, in the flatness of the ilia, and the essentially total disappearance of the spinous processes of the sacral and lumbar vertebrae, lost practically every feature which would make it functional in the assumption of an erect posture.

The character of this pelvis then lends support to the historical probability that the existing sloths are survivals from some remote ancestor which escaped extinction by small size and the adoption of truly arboreal habits. This pelvis may then be most probably explained as a rudimentary persistence of characters which have ceased to be of functional value.

The **Ungulata** are a highly specialized order, and in the Ungulata vera, at all events, they are a very homogeneous order, both in habits and configuration.

They are all digitigrade, quadrupedal, and terrestrial; none of them make use of an erect posture, and their skeletons are throughout highly specialized towards cursorial speed.[1]

Their pelves all have the essentially straight, and usually long, quadrupedal, ilio-ischiatic axis.[2] Their ischia, pubes, and sacra are strictly quadrupedal in type.

Their iliac shanks are, as a rule, unusually long (a quadrupedal character), and in the Artiodactyla, at least, have a peculiarly quadrupedal cross section. The blades have, almost without exception, well developed and often extensive quadrupedal plates, which often form a large portion of the blade, but in the Perissodactyla and Proboscidea the ventral and usually somewhat larger portion of the very wide blade is furnished by a true anthropoidal plate, while the Artiodactyla have a plate of similar shape which is probably developed from the fused ventral and external edges [3] (Figure 4, VI). In certain of the heavier animals the blades often have well developed crests.

The appearance in these exclusively quadrupedal animals of wide and laterally extended blades, formed in some cases by a true anthropoidal plate, is a marked exception to the general rule that this plate is only developed by animals which use an erect posture. This would be a severe blow to the general argument in the text if there were not an adequate mechanical reason for its appearance here. As it is, perhaps this is a case in which the exception proves the rule, and supports that argument.

We have seen that one of the functions of the laterally expanded

1 The Hyracoidea are to be noted as exceptions to several of these statements, but as the propriety of their inclusion in the order is doubted, and as their pelves in particular show quite as many rodential as ungulate characters, they are neglected here.

2 The metischial processes, or metischial curves, which occur in some of them as extra specializations for leaping, have been mentioned in the text.

3 In the absence of any really primitive ungulates this statement must be put forward a little cautiously, but certain Bovidae appear to furnish transitional stages between the blades of the Perissodactyla and those of the Artiodactyla.

blade, and the chief function of its crest, is in furnishing direct and advantageous leverage to the muscles of lateral flexion of the trunk.

This is, as has been seen, of great importance to the balance of the erected trunk, but we have here quadrupedal animals in whom the lateral flexions of the trunk are extremely important elements in the quadrupedal speed, on which their preservation mainly rests.

The Ungulata as an order are preponderantly trotters or pacers, gaits in which the hind legs are used in strict alternation.

In both these gaits the animals when at speed lengthen the stride and increase its power by strong, alternate, lateral flexions of the lumbar spine, and the lives of most ungulates are preserved from their enemies only by their speed.[1]

The laterally extended iliac blades of the Ungulata then perform an exactly similar function to that which they execute in the erect animals. They give power and direct action to the muscles of lateral flexion, which here again are all-important necessities.

The degree of lateral expansion of the blades and crests in the ungulates is, moreover, proportional to the weight and speed of the several groups, and to the degree in which they are preponderantly trotters or pacers.

They reach their maximum extent and even turn ventrally and inwards as they approach the region of the anterior superior spines in the Elephantidae, which are among the heaviest of terrestrial animals; never use any other gait than the pace, even when pressed; are very fast, and can remain at speed for exceedingly long distances. They use a considerable amount of lateral, lumbar flexion even when moving slowly, and this is said to become very great when they are at speed.[2] They have long

1 It is well known, too, that even in the gallop the hind legs are not used simultaneously, but in an approach to alternation, and often with some lateral flexion of the trunk toward that limb which is in the lead at the moment.

2 The wide lateral expansion of the human iliac blades is sometimes attributed to the superincumbent weight of the intestines and a necessity for their support in the erect posture, but this influence, if existent, seems unlikely to be more than an auxiliary. In point of fact the writer's X-ray studies of the position of the pelvis in the erect posture of living subjects show conclusively that the blades are parts of the posterior wall of the abdomen and overhang, rather than support, the pelvic contents. Certainly no one would attribute the equally wide spread of the elephant's ilia to the superincumbent weight of his intestines.

legs and their very long strides are lengthened and increased in power when they are at speed by dorso-ventral flexions of the lumbar spine. The ventral prolongation of the iliac crests which is peculiar to them is an evident adaptation to the performance of this motion.

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